Author:
Duncan, Karen

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Factors associated with dental disease and development in preschool children.

FACTORS ASSOCIATED WITH DENTAL DISEASE AND DEVELOPMENT IN PRESCHOOL CHILDREN

Karen Duncan

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Abstract

Much of the available information regarding the dental status of preschool children has been gained via cross-sectional studies, which fail to present a true picture of trends within a population. This study took advantage of the prospective, population-based Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC), which enrolled pregnant mothers with an expected delivery date between April 1st 1991 and December 31st 1992 and who were resident in the 3 Bristol-based health districts of Avon. ALSPAC holds a wealth of longitudinal information about 14000 mothers and their children gained via questionnaires. In addition, a cohort (Children in Focus) was regularly examined in a clinic environment where aspects of growth and development were recorded.

The current study reports caries experience, occlusal development, and erosion using dental data collected when the children were 31-, 43- and 61-months old.

The caries experience increased from 3% at 31-months to around 23% at 61-months.

The influence of socio-demographic factors and diet on the development of caries and erosion were investigated. Children born to younger mothers with low educational levels and living in council accommodation were more likely to develop caries. Erosion was more prevalent in children living in council accommodation and with younger mothers.

A persistent dummy or digit habit up to 36-months of age was shown to have a significant effect on anterior occlusion and posterior crossbite at 43- and 61-months.

Longitudinal studies are notoriously difficult to set up and the running costs are high. Dental survey data are currently collected by dentists at considerable expense. This study used auxiliary staff to collect data and that collected was considered to be of an acceptable standard. The task of maintaining the interest of participants is enormous. Nevertheless, the ALSPAC study continues to attract peer-reviewed grant support and is likely to continue for the foreseeable future.

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No more excuses...I have finished.

Author's Declaration

I declare that the work in this dissertation was carried out in accordance with the Regulations of the University of Bristol. The work is original except where indicated by special reference in the text and no part of the dissertation has been submitted for any other degree. Any views expressed in the dissertation are those of the author and in no way represent those of the University of Bristol.

The dissertation has not been presented to any other University for examination either in the United Kingdom or overseas.

Signed:.. Date: ....

Karen Duncan

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CHAPTER 1

LITERATURE REVIEW

1.1 Introduction

The ability to predict areas of dental need is essential when planning the level of and accessibility to dental care in a community. The World Health Organisation's (WHO) global goals for oral health for the year 2000 (Fédération Dentaire Internationale 1982) included the aim that 50% of 5-6 year olds should be caries-free and that 12-year-olds should have no more than three decayed, missing or filled permanent teeth (DMFT$\leq$3.0). A progress report (Leopold *et al.* 1991) indicated that these goals were likely to be achieved in developed countries but rather worryingly, the trends in caries experience (*dmft* of primary teeth) in 5-year-olds in the United Kingdom are changing with caries levels remaining constant or slightly increasing (Murray and Winter 1998).

The United Kingdom's National Health Service was established in 1948. Since then, the dental health of the nation has been closely monitored through oral health surveys. A steady improvement in dental health and a decline in dental caries have been reported from 1948 with more adults remaining dentate (Murray 1998). Similar trends have been seen in schoolchildren (Miller 1950, Todd 1975, Todd and Dodd 1985, O'Brien 1994). However, there is some frustrating evidence that the decline in caries experience in 5-year-olds has levelled out since the early 1980s (Rugg-Gunn *et al.* 1988, Downer 1992, Silver 1992, Murray and Winter 1998). Information regarding the dental health of preschool children is limited because of a lack of longitudinal data. It is difficult, therefore, to obtain a true picture of changing trends within the same population.

Dental caries and dental erosion are two major dental diseases which affect the dentition of children. These conditions have very different aetiologies, although dietary factors play an important part in both. The prevention of these conditions is dependent upon the knowledge and education of the parents (Blinkhorn 1982), since habits learnt at a young age are likely to stay with the child.

The relationship between dental caries and socio-demographic and dietary factors is well known. Dental caries prospers in an environment of poor oral hygiene and high frequency of sugar consumption. It is more prevalent in those in lower socio-economic groups and pockets of increased levels of dental disease are found within all communities. The relationship between poor oral hygiene practices in children and dental caries is well documented (Winter 1988, Stecksén-Blicks and Holm 1995). In preschool children, emphasis is placed on nursing or bottle caries. This manifests as caries primarily affecting the maxillary incisors and is the result of poor dietary habits and feeding patterns (Silver 1987, Holt and Moynihan 1996). Maxillary incisor caries is a predictor of caries in primary molars (O'Sullivan and Tinanoff 1993). Caries progresses to affect the primary molars unless feeding habits are modified.

In 1993, the prevalence of dental erosion was included in the criteria for the Child Dental Health Survey of 5-year-olds (O'Brien 1994) and was also recorded in the National Diet and Nutrition Survey (Hinds and Gregory 1995).

Trends indicate that the consumption of soft drinks with erosive potential in young children is increasing. The effects on the permanent dentition may be severe and require extensive intervention. The presence of erosion in the primary dentition may be a predictor of disease in the permanent dentition and longitudinal information may provide valuable information in the identification and management of the future health of disease-susceptible children.

The development of a functional occlusion also contributes to a socially acceptable level of dental health. In addition to diseases of tooth tissue, anomalies in occlusal development may require extensive orthodontic correction, involving considerable patient and operator time, cooperation and cost. The effects of non-nutritive sucking habits on occlusal development have been extensively reviewed (Johnson and Larson 1993, Moore 1996), although little longitudinal data is available in the United Kingdom.

1.2 Data collection

In the United Kingdom, the collection of dental survey data has historically been carried out by qualified dentists, with considerable financial burden (Mitropoulos *et al.* 1990). The British Association for the Study of Community Dentistry (BASCD) developed standard survey criteria in 1983 which are used in dental health surveys (Todd and Dodd 1985, O'Brien 1994). The criteria are under constant review in the light of their interpretation and use across the United Kingdom (Pitts *et al.* 1997, Pine *et al.* 1997a). BASCD criteria are not standardised with those of the WHO. However, every effort is now being made to resolve this. These surveys employ many qualified dental officers and the costs are high. All staff are trained and calibrated to a specified standard prior to each study (Pine *et al.* 1997b).

In countries such as Canada, parts of the USA and the Netherlands dental auxiliaries are employed to diagnose and treat dental disease in children and they are also used for data collection in dental surveys. Studies have shown that auxiliaries can be trained to an acceptable standard for data collection (Howat and Cannell 1979, Kwan *et al.* 1996, Kwan and Prendergast 1998).

In the United Kingdom, dental auxiliaries (hygienists and therapists) are only permitted to work under the written prescription of a dentist (General Dental Council 2000). They may not diagnose dental disease, merely treat it. If auxiliaries were able to collect survey data, then this would cut costs and enable dentists to use the time saved to carry out treatment.

Until recently, dental hygiene courses were of one-year duration, although this has now changed to two years. Nevertheless, hygienists' salaries are less than those of therapists and therefore cost savings would be achieved if they could reliably collect data. On this basis, Howat and Cannell (1979) compared the reliability of hygienists and dentists in the collection of dental data. They found little difference in reliability when teeth were obviously cavitated, although the hygienist had difficulty in determining early enamel lesions.

Kwan *et al.* (1996) looked at the feasibility of auxiliaries collecting dental data from 5-year-old children in the United Kingdom and found that they were able to record data comparable to that of a dental officer who was regarded as the 'Gold Standard'. In fact, the three auxiliaries in this study produced higher kappa values than two of the dentists, one of whom failed to reach the minimum BASCD standard of kappa (0.75). The study involved training the staff to BASCD criteria using one half day of classroom work and one day of clinical examination. This training fine-tunes the existing knowledge of the staff and attempts to eradicate misinterpretation of the criteria. Epidemiological survey criteria are very different from those of caries diagnosis as the former employ strict diagnostic guidelines, whereas the latter use a number of subjective decisions regarding the clinical extent of the disease. It is well recognised that although overt cavitation is easy to determine, dentists will often disagree with and amongst themselves in the diagnosis of early enamel lesions (Merrett and Elderton 1984). A record of overt cavitation which is made using study criteria does not necessarily indicate that a dentist should carry out treatment for that individual, but recommends further examination with clinical and diagnostic tests, under strict surgery conditions. Since the personnel who collect survey data are trained and calibrated beforehand, then it may be possible to train non-dental staff to record pre-determined criteria. Satisfactory data collection by these staff could result in a lowering of costs for the surveys.

A further study compared the data collection of a group of hygienists with a group of therapists (Kwan and Prendergast 1998). All observers had more than 8 years post-qualification experience of dealing with 5- and 12-year-old children. The results show that auxiliaries can be trained and calibrated to reliably collect data in 5-year-olds and this supports the findings of the earlier pilot study (Kwan *et al.* 1996). However, the results for the examination of 12-year-olds suggest that more training might be required and this is probably due to the presence of the mixed dentition and the broader range of treatment that may have been carried out in this age group. These findings were not supported by Hawley *et al.* (1999). However, their study used only three examiners (one hygienist, one newly appointed dentist and one experienced dental epidemiologist). It may be that the training programme used was insufficient for this hygienist, although may have been adequate for another or indeed, that the programme should be modified to allow for the disparity in diagnostic skills between a dentist and hygienist.

Few studies have investigated the reliability of non-dental personnel in data collection. In one study, a dental hygienist and registered nurse with no dental experience were trained in simple caries diagnosis (Beltrán *et al.* 1997). Training involved the use of written material as well as clinical slides and patients. Data were collected from children who were between 5 and 12 years of age, with screening procedures that used predetermined criteria. The examiners decided whether a tooth was sound, carious or restored. Further information was gained from multiple-choice questionnaires completed by the parents. The study concluded that observations by non-dental personnel could be highly valid provided that the criteria were clear and simple and that appropriate training was given.

1.2.1 Extended duties of auxiliaries

In New Zealand, School Dental Nurses are trained to diagnose and plan treatment. Since 1920, they have been able to provide care for children under 16 years of age. In Denmark, denturists make dentures. In the United Kingdom, restrictions apply with regard to the duties that may be performed by dental auxiliaries. These restrictions are regulated by the General Dental Council. Canada and parts of America already train such staff (Yap 1993) and Canadian dental hygienists who train at the Birmingham Dental School undertake a 10-day training course of extended duties (Turner and Pinson 1993) to prepare them for work in their homeland. More recently, a pilot study (Stephens *et al.* 1998) reported favourably the feasibility of training United Kingdom dental nurses to perform extended chairside duties in the role of orthodontic auxiliaries. The necessity for training these auxiliaries was also discussed (Atack *et al.* 1999).

Rosenblum (1971) reported that dental nurses who were given a 3-month training programme in expanded paediatric dental procedures performed as efficiently as final year undergraduates. This work was supported by that of Lotzkar *et al.* (1971) who maintained that a dentist could increase productivity by 130% if an auxiliary was employed to help. It has been suggested that efficient and effective management of the practice and the hygienist is paramount to ensure cost-effectiveness (Walsh 1987). In Norway, any work that can be carried out by a dental hygienist is delegated. This enables dentists to use their clinical time more productively and is therefore more cost effective (Wang 1994). Areas of low caries are identified and these are the areas that can often be just as efficiently serviced by the hygienist as the dentist. In these cases, recall times can be extended without detriment to the oral health of the patients (Wang and Riordan 1995).

1.3 Dental caries

1.3.1 Prevalence of caries in the preschool child

In a review of trends in dental health since the end of the 19th century, Gelbier (1998) highlighted changing patterns of caries in the United Kingdom. At the end of the 19th century, caries levels were higher in the more affluent classes. This was attributed to the high sucrose consumption of these groups, the cost of which was prohibitive to poorer groups. School screening was introduced in the United Kingdom in 1907 and was carried out by the School Dental Service. During the following fifty years, survey criteria were refined and improved. Surveys continue to be carried out by the Community Dental Service following criteria laid down by the British Association for the Study of Community Dentistry.

At the inception of the National Health Service in 1948, the incidence of caries in the primary dentition of the lower social classes was increasing (Wilkins 1941). This was assumed to be due to sugar and confectionery becoming more widely and cheaply available following the end of World War II. Miller (1950) found higher levels of caries in the primary molars than incisors in 100 Manchester-based children aged 3 to 15 years, over a period of one year. The primary caries levels increased throughout the duration of the survey and this was also attributed to the increased availability of sugar.

Current BASCD survey criteria record the dental caries in samples of 5- and 12-year-old children at 10-yearly intervals and provide a picture of trends in dental health. Standardisation of study criteria provides information for planning of services (Palmer *et al.* 1984).

In 1973, the mean caries experience (*dmft*) of 5-year-old children in England and Wales was 4.0 and 30% of children were caries-free (Todd 1975). A significant decrease in the prevalence of caries occurred during the next decade and in 1983 the mean *dmft* of 5-year-olds was 2.1 with 50% of the children caries-free (Todd and Dodd 1985). The WHO global goals for the year 2000 (Fédération Dentaire Internationale 1982) had been achieved in England and Wales in 1983, but not in Scotland and Northern Ireland. The following ten years (1983 - 1993) produced very little improvement in the dental health of 5-year-olds (O'Brien 1994). In 1993, the mean *dmft* of 5-year-olds in England and Wales was 2.0 and 55% of children were caries-free, whilst in Bristol and District, the mean *dmft* was 0.92, with 70% caries-free (O'Brien 1994). The strongest association was seen between the *dmft* and the dental attendance of the children, with poorer attenders having higher caries experience than regular attenders. In 1983, 23% of children had some restored teeth and this proportion had decreased to 15% in 1993 (Murray 1998). This reduction in treatment may be attributed to the introduction of capitation in 1988 (Coventry *et al.* 1989), which included a payment to the general dental practitioner toward the provision of a maintenance programme for the child.

The four valuable studies of dental caries in preschool children in Camden, United Kingdom, provide evidence of trends in dental health over four decades (Winter *et al.* 1971, Holt *et al.* 1982, 1988, 1996). The data available from these studies include social background, oral hygiene and dietary habits, including the use of sweetened comforters. In each of the studies, the highest prevalence of caries was found in the lower social classes. Social class was assessed using the Registrar General's Classification of Occupations and the father's occupation. In 1966, 64% of children were caries-free and this increased to 72% in 1986. Very little change was seen during the following period and only 70% of children were caries-free in the 1993/1994 study. Similar trends have been reported elsewhere in Britain (Cushing and Gelbier 1988) and Europe (Truin *et al.* 1991, Stecksén-Blicks and Holm 1995).

Since 1989, there has been a levelling-off of caries experience in the primary dentition in European countries, although caries has continued to decline in the permanent dentition (Downer 1992, Murray 1998). Other changes have been seen such as a slowing in the increase of sales of fluoride toothpaste, although little change has occurred in sugar consumption (Downer 1992).

1.3.2 Aetiology of dental caries in the preschool child

Dental caries occurs in the presence of four predisposing factors (Newbrun 1989). These are: a susceptible host (teeth), substrate (fermentable carbohydrate), bacteria (mainly streptococci and lactobacilli) and time.

Fermentable carbohydrates, such as non-milk extrinsic sugars, are converted to acid by the action of micro-organisms, primarily Streptococcus mutans (S. mutans). The acid reduces the plaque pH allowing cariogenic attack and enamel demineralisation to take place. The buffering capacity and flow rate of saliva influence the length of time that the plaque pH remains below the critical level of 5.5. The average time for normalisation of the pH level is 30 minutes. Therefore, repeated carbohydrate intake and subsequent prolonged lowering of the pH, will result in potentially damaging cariogenic activity (de Soët and de Graaff 1998).

1.3.2.1 Microbiology of dental caries

S. mutans and lactobacilli are the predominant micro-organisms in the development of caries (van Houte 1980, 1994). S. mutans has been associated with the development of early carious lesions and lactobacillus with the progression of lesions into dentine (Demers *et al.* 1990). These bacteria are acidogenic and rapidly ferment carbohydrate to produce acid, lowering the pH of saliva. They thrive in acid (aciduric) and adhere to teeth using the acquired pellicle. All sugars can be broken down to produce acid and are therefore potentially cariogenic. Sucrose is considered to be the most cariogenic as it is readily available in many food products and can be converted to acid more quickly than others, such as glucose, fructose and lactose.

i. Actions of Streptococcus mutans and lactobacillus

S. mutans requires a non-shedding tooth surface on which to colonise (Gibbons and van Houte 1971) and does not adhere to oral epithelial tissue, whereas lactobacilli need retentive sites such as pits, fissures and carious lesions. As a result, S. mutans is rarely seen in children prior to tooth eruption and lactobacilli are found less frequently in young children until the primary dentition is established.

ii. Colonisation of the child

Levels of oral colonisation of S. mutans increase with age and are dependent on the number of erupted teeth. Initial colonisation is due to inoculation by the mother (de Soët and de Graaff 1998) and can take place from 10 months of age (Karn *et al.* 1998) to beyond 3 years (Köhler *et al.* 1984). Caufield *et al.* (1993) suggested that children could become colonised with S. mutans between 6 and 24 months of age, whilst the teeth were erupting, and then not until 6 to 12 years when the permanent teeth erupt. In their study group, 50% of children who were not primarily cared for by their biological mother between 1 and 2.5 years of age were not colonised with S. mutans. The level of S. mutans in the mother was shown to be associated with that of the child and a high maternal count predisposed the offspring to be similarly colonised (Köhler *et al.* 1984). The mothers of those children who were colonised by 1 year had established behaviour patterns such as giving nocturnal sweetened drinks and were more likely to have breastfed the child beyond 10 months of age (Grindefjord *et al.* 1991).

Köhler *et al.* (1984) selected mothers with a known high count of S. mutans. The mothers were divided into a control (high levels of salivary S. mutans) and test group (low levels of salivary S. mutans). The children were regularly monitored from the age of 15 months. Records were kept of social background, dietary habits and microbiological content of the saliva. It was found that 77% of the children who had been infected at an early age developed dental caries. Only 3% of those with no S. mutans at three years developed caries compared with 51% of those who were colonised with S. mutans. Van Houte *et al.* (1981) found only a weak association between maternal levels of S. mutans and levels in children between 5 and 8 years old. This association was only seen when the groups were divided into caries-free and caries-positive children. Roeters *et al.* (1995) also found little significance in maternal S. mutans levels and caries, but found better correlation between mothers with low educational levels and high caries prevalence in the children.

Köhler *et al.* (1984) found lactobacilli in around 40% of the children regardless of the maternal level of salivary S. mutans, although slightly higher levels were noted in the children with caries. Those who had received fluoridated water had high levels of S. mutans, but lower than average levels of dental caries; these figures were not related to social class. Ollila *et al.* (1997) examined 166 children between 1 and 4 years of age for evidence of lactobacilli and candida. Lactobacilli levels were significantly associated with a dummy sucking habit and therefore the habit could potentially be implicated in the progression of caries.

iii. Control of Streptococcus mutans levels

If preventive measures are used to decrease the level of S. mutans in the mother, then there could be a delay or possibly a total absence of colonisation in the child (Köhler *et al.* 1984). Some reinforcement of this idea comes from the work of Twetman *et al.* (1999) who investigated the salivary levels of S. mutans and lactobacilli in a survey of Swedish preschool children. The children were about to undergo a dental anaesthetic for removal of multiple carious teeth. Levels of S. mutans and lactobacilli, as well as the buffering capacity of the saliva, were recorded prior to operation, and then checked at one month and 6-months post-operatively. The study showed a significant association between reduction in S. mutans levels and the number of teeth extracted. No significant association could be demonstrated between lactobacilli levels and treatment received. These findings suggest that if extraction treatment is followed by an intensive preventive regime, then further cariogenic activity may be reduced.

iv. Development and progression of caries

Caries may develop within 2 to 2.5 years of colonisation with S. mutans (Newbrun 1989) and high levels of salivary S. mutans are seen in cases of nursing bottle caries (Berkowitz 1996, Alaluusua *et al.* 1990, 1996). The earlier the child is colonised by S. mutans, the higher prevalence of caries. This was demonstrated in children as young as 4 years of age, who had more interproximal lesions than those colonised later (Köhler *et al.* 1988). If a child has not been colonised by 3 years of age only minimal caries is seen at 5 years (Roeters *et al.* 1995).

There are also social and racial factors associated with the development and progression of caries. Thibodeau *et al.* (1993) measured salivary S. mutans levels in preschool children in the lower socio-economic groups and found high S. mutans levels associated with high caries incidence. There was also evidence to suggest higher levels in black and Hispanic groups compared with white children.

1.3.2.2 Dietary sugars in the aetiology of caries

Laboratory experiments and epidemiological, human clinical, animal and plaque pH studies have all contributed to the implication of sugar in the aetiology of dental caries (Rugg-Gunn and Edgar 1984). Both the frequency of consumption of sugar and the consistency of food products are important factors in the development of caries as demonstrated in the classic Vipeholm study

(Gustaffson *et al.* 1954). Low caries levels are seen in people with fructose intolerance (Newbrun *et al.* 1980), which further demonstrates the cariogenic nature of sugars. Marked changes in diet have been associated with changes in caries experience.

Tristan de Cunha is a small island off the coast of South Africa near Cape Town. Sparsely populated, the main industry is fishing and until the 20th century the diet of the islanders consisted of fish and potatoes. Early dental studies showed that the islanders had no dental caries in the 1930s. However, the situation changed dramatically by 1950 with almost every islander having multiple lesions, particularly the young children (Holloway *et al.* 1963, Fisher 1968a, 1968b). The change was attributed to the improved fishing industry and wealth of the island coupled with the arrival of a naval base, which led to a large increase in imported foodstuffs, including sugar, confectionery and cakes.

The Committee on Medical Aspects of Food Policy report (1989) implicated all foods as potentially carious but this is misleading. It is the speed with which sucrose can be fermented which is fundamental in the aetiology of caries (Rugg-Gunn 1990). Starches are cleared away by saliva before acid can be produced. Limiting the frequency of sugar consumption is an important step toward the prevention of dental caries (Levine 1996). Potentially caries could arise from hidden sugars and if so then there is clearly a need to improve the labelling on foods that contain sugar. Food manufacturers should also be encouraged to decrease the amount of hidden sugars in food products.

A review of recent sugar consumption and caries experience (DMFT) in 12-year-olds in 90 countries found that DMFT increased as sugar consumption increased. However, caries and sugar consumption were not significantly related and this was attributed to the effects of other dietary factors and the use of fluoride (Woodward and Walker 1994).

1.3.2.3 Dietary habits of preschool children

A survey of the diet of preschool children in the United Kingdom in 1967-68 showed that 64% of children were receiving less than the recommended daily intake of energy (Committee on Medical Aspects of Food Policy 1975) with 20% of this reduced intake being derived from non-milk extrinsic (added) sugars such as jam, honey and other preserves. Children born within large families were also more likely to receive higher sugar intakes.

From a nutritional point of view, repeated small intakes of energy-producing food are recommended (Committee on Medical Aspects of Food Policy 1994). However, repeated cariogenic attack and decrease in plaque pH contradicts sound dental dietary advice, particularly in children who are at risk of developing caries. At night the salivary flow rate and oral clearance decrease. Therefore bedtime eating and drinking should be discouraged in the young child (Palmer 1971).

Persson *et al.* (1985) studied infant feeding habits at 1 year of age and compared these with the dental caries levels of the children at 3 years. Even at a young age, the children of mothers educated to a higher level were eating a less cariogenic diet than children of mothers with a lower educational level. Caries experience was related to the maternal educational level; the higher the level the lower the caries. Therefore, attempts should be made to educate mothers when the child is very young (12-18 months) as dietary patterns become established. Wendt and Birkhed (1995) similarly showed that children with and without caries at 3-years had significant differences in their diets at 1-year of age.

Information on the diet of preschool children and its links with caries in the primary dentition is limited. Work by Marques and Messer (1992) failed to demonstrate associations between individual foodstuffs, including sugar consumption.

Stecksén-Blicks and Holm (1995) found 4-year-old children consumed more buns, cakes, ice cream and sweet drinks than sweet confectionery. Frequent snacking and irregular brushing predisposed the child to a higher caries experience than a child who rarely snacked and brushed regularly. This suggests that irregular brushing exacerbates the effects of frequent snacking.

It is not only foodstuffs which are cariogenic. Drinks are often a source of sucrose. Many infant fruit drinks have a low pH, which will accelerate the acidic attack on the enamel surface. Mothers should be made aware of the potential damage caused by prolonged and frequent intake of these drinks and of the fact that even those labelled as 'no sugar added' or 'sugar-free' are cariogenic (Duggal and Curzon 1989).

1.3.3 Site of carious attack

Fass (1962) first coined the term 'nursing bottle mouth'. He described the phenomenon in great detail and although other terms have been used to describe it, such as early childhood caries (ECC) (Tinanoff 1998), it remains a condition easily recognised by the dental profession. Despite the widespread nature of the disease, studies provide conflicting evidence regarding the aetiology and prevention (Tinanoff and O'Sullivan 1997) and the prevalence world-wide (Ripa 1988). This is due in part to the different definitions of the number of teeth that should be included and differing diagnostic criteria (Ismail and Sohn 1999). Ismail (1998a) has suggested that any child with even one carious lesion at 3 years of age should be considered as having ECC and therefore a high caries risk.

Classically, children with ECC have poor dietary habits. The child is put to bed with a bottle of milk, either at night or for a nap. The resulting pattern of destruction is dictated by the eruption of the teeth. It is known that caries manifests in an environment of fermentable carbohydrates (milk) and micro-organisms (S. mutans). The decreased salivary flow as the child sleeps slows clearance of the milk and if the bottle stays in the mouth then the milk continues to be delivered as a slow trickle. This provides the element of time required for caries to establish itself. Feeding habits like this may continue until the child is 3 or 4 years of age, despite weaning recommendations to the contrary (Holt and Moynihan 1996). Parents initially become aware of the damage when they notice a mark on the front teeth or when the child shies away from toothbrushing or from eating or drinking.

If maxillary incisors are carious then there is an increased risk of caries in the primary molars (O'Sullivan and Tinanoff 1993, Al-Shalan *et al.* 1997). This may be due to the presence of S. mutans and a combination of other factors such as poor oral hygiene, poor dietary habits or the mother's inadequate knowledge of dental care.

If primary molars are carious at 5 years of age, then there is a higher risk that the first permanent molars will be affected at 7 years (Gray *et al.* 1991).

Others have noted the progression of caries with age. Hennon *et al.* (1969) looked at the prevalence and distribution of caries in 915 children between 18 and 39 months of age. They found that although 92% of 2-year-olds were caries-free, only 43% of them remained caries-free at 3 years. Caries affected mainly upper and lower second primary molars and upper central incisors, with lower second molars being the most common teeth extracted due to caries.

1.3.4 Development of feeding habits

Weaning normally begins at around 4 months and the diet is gradually expanded to include food and drinks other than breast milk or infant formula. The Committee on Medical Aspects of Food Policy report (1989) recommends low levels of non-milk extrinsic sugars during weaning, including those in fruit juices and concentrates. Recommendations for weaning are to give 'solids' with a spoon rather than in a bottle (Holt and Moynihan 1996) and not to add sugar to any foods or drinks. Nocturnal bottles are not advised. Children should be encouraged to drink from a cup as early as possible. Baby drinks are given initially with a progression to fruit squashes. However, some children are given adult drinks with artificial sweeteners as a substitute for fruit drinks. Parents are advised to give non-cariogenic snacks wherever possible and foods such as cakes and biscuits at mealtimes only, although not every day. Meals should provide sufficient energy and nutrients for normal growth and development. By 12 months the child should be receiving 3 well-balanced meals per day plus non-cariogenic snacks and milk. Holt and Moynihan (1996) reported that 86% of children ate biscuits as snacks at 9 months. Yoghurt was a popular food, which often contains high levels of sucrose. Sweets and chocolate were given in small quantities, but were introduced at a young age.

Differences in the caries experience of preschool children had previously been attributed to differing parental attitudes toward feeding and the use of sweet drinks in bottles or comforters (Silver 1974). Children with less caries appeared to have better drinking habits and received less frequent intakes of sweet drinks.

1.3.5 Barriers to dental care

Inequalities exist in the dental health of preschool children, which may be attributable to social class and deprivation (Watt and Sheiham 1999).

Poor dental attendance contributes to poor dental health and poor oral health knowledge. To improve attendance, the barriers to dental care must be identified (Rogers *et al.* 1984). Barriers may include geographical restraints as well as age, race and income.

1.3.5.1 Social class and dental caries

A decrease in caries experience of 3-year-olds, over an 8-year period, has been recorded (Silver 1982). The reduction in caries took place in all social classes, although the greatest decrease was within the lower social classes. The improvement was attributed to an increase in the frequency of toothbrushing and the initial dental visit occurring at a younger age.

In a further study, Silver (1987) reported the dental status of children at 3 and 8 years of age. Children in the lower social classes had poorer feeding habits and more caries at both ages. Teeth had been extracted rather than restored. Poor infant feeding habits are an indication of probable continued sugar abuse and therefore oral health programmes should target these families. In a third study of 3-year-olds (Silver 1992) the children began to brush their teeth at a younger age and more frequently than in the earlier studies. An improvement in feeding was seen, with fewer children having sugar added to their bottle, despite an increase in the use of unsweetened comforters. These findings were class related. The improvements in caries experience were thought to be due to the increased use of fluoride toothpaste, improved toothbrushing habits and an increased awareness of good oral hygiene and feeding practices.

Mothers in lower socio-economic groups are more likely to use sweets and other confectionery as bribes to keep a child quiet or as a show of affection, compared with those in higher socio-economic groups who tend to use sweets as rewards (Blinkhorn 1982). The children from lower socio-economic groups are more likely to be given sweets immediately following a day at nursery and are also more likely to eat sweets throughout the day. Holt (1991) substantiated these findings in her study of inner-city London. She found that 71% of children ate snacks. Sweet biscuits were the most popular snack, whilst fruit squash was the most popular drink consumed by 40% of the children, although 91% reported drinking soft drinks. More children in the lower social classes drank fruit squash and ate sweet biscuits throughout the day, particularly in the evening, and 65% of the children had three or more snacks a day. Those children who snacked most frequently had a greater caries experience. Only 11% ate immediately before bedtime, although 50% had a drink at this time.

Snacks and drinks between meals are regular dietary patterns in young children. Many popular items contain sugar and the consistency may vary, for example, wafer, caramel, chocolate and so on. The caries levels are related to the frequency of food and drink consumption as well as the social class of the children. Blinkhorn (1982) also reported an element of 'community expectation' with mothers in the deprived areas assuming that their children's friends were eating in a similar pattern. Children in the more affluent areas (42%) recorded a preference for savoury snacks or fruit, compared with only 10% of the children in the deprived areas. Grandparents viewed sweets as an expected treat with 83% giving sweets to children in both groups. Both groups of children liked and drank carbonated drinks. The findings of the study were reflected in the lower levels of dental caries recorded in the more affluent communities.

The frequency of sugar consumption increases with the age of the child (Rossow *et al.* 1990). Initially the higher-educated mothers restrict sugar.

However, as the child becomes more independent and mixes with other groups, the effect of the mother's education is diminished.

The attitudes of British mothers in the lower social classes to dental and medical care have been reported (Kay and Blinkhorn 1989, Hendricks *et al.* 1990). Older mothers (greater than 25 years) were more likely to take their children to the dentist and exercise good preventive practices compared to the younger mothers. Whilst acknowledging that correct dental care would prevent dental caries, younger mothers associated dentists with pain and discomfort based upon their own previous experiences. Hood *et al.* (1998) found the oral health knowledge of mothers in lower social classes to be poor. This supports other work (King *et al.* 1983, Paunio *et al.* 1993a, Paunio 1994). Mothers recognised the cause of dental caries to be poor oral cleanliness, but only 50% understood the role of dietary sugar in the aetiology of caries. They were often unaware of the dental needs of their children and of the importance of regular dental attendance.

Mothers in the higher social classes who have a good knowledge of dental health use it to the benefit of their children, denying food or drink that they know is bad for their teeth (Beal and Dickson 1974).

The National Diet and Nutrition Survey (Hinds and Gregory 1995) examined a cross-sectional sample of 1.5 to 4.5-year-olds who were living in private households in the United Kingdom between September 1992 and September 1993. Extensive social and dietary data were obtained. A strong statistical association was demonstrated between dental caries and social background with increased prevalence in the lower socio-economic groups.

1.3.5.2 Ethnicity and dental caries

Ethnic variations in diet are common. In Asian culture, children are bottle-fed custard or rusks, both of which contain sucrose and this habit may continue until the child starts school. Consequently, ethnic differences in caries levels are seen in the primary dentition (Freeman *et al.* 1989, Prendergast *et al.* 1997, Prendergast and Williams 1999). A study of the dental health of black, white, Hispanic and Asian preschool children (Freeman *et al.* 1989) showed 2-year-old Asian children to have higher caries levels than the other children and this difference was even greater when the children were 5-years-old. Hispanics also had higher caries levels than white and black children. White and Asian children were more likely to have attended the dentist, but for different reasons. Asians were likely to have attended because of the symptoms caused by a very high caries rate.

1.3.6 Dental need

Assessing dental needs may be unreliable if conducted by the profession, since the professional interpretation will differ from the users' (Sheiham *et al.* 1982). The public's attitude towards oral health and the importance it places on seeking dental care must be considered.

Davis (1982) proposed a model for the assessment of service requirement which included the 'needs' of the public as assessed by the profession, 'wants' as assessed by the people and 'demands' based on the requests for care. Although oral health can be assessed using epidemiological surveys, people may not utilise the services provided if they feel that treatment is not necessary. If all health needs were fully met, then the cost would be prohibitive. However, if care were focused on those with the greatest need and those who would benefit most from treatment, then the overall benefits would outweigh the costs incurred. However, if the public identifies its own needs and subsequently formulates its own demands then this is the cheapest option because fewer resources will be required. Should the profession choose to target those who have 'wants' but have not yet made 'demands', it may be appropriate to take dental care to them either at school or the work place.

In areas of the United Kingdom where the dentist to population ratio is poor, the best uptake of dental care comes from within the higher social classes. However, when the ratio is good, all social classes seek treatment in similar proportions (O'Mullane and Robinson 1977). Therefore, it might well be that the availability and accessibility of dentists contribute to this disparity.

Whilst dentists cannot change the social class of individuals, the profession can ensure improved access to dental care for those in the lower socio-economic groups. It is well recognised (Beal and James 1971) that those who would gain the most benefit belong to the very groups that either have no access to dental care or do not search for dental treatment until a dental emergency arises.

In Norway, priority has been given to the delivery of oral health care to those who require it, by providing access to free public dental services for children, adults and the elderly (Holst *et al.* 1997a). An equal distribution of services delivered with economic efficiency would be the ideal. The model used in Norway is intended to benefit both the patient and the carers as a result of improvements in the oral health of the patient. As children cannot easily assess their own needs, it is important for the profession to determine levels of adequate service. The *dmft* gives an indication of current and past levels of disease. However, it does not provide a clear picture of future needs. Assessment of oral health should determine whether improvements are due to the efficiency of the service or the individual's health knowledge and behaviour.

1.3.7 Dental attendance

In a review of dental deprivation in inner-city Newcastle, Carmichael (1985) showed that socially and economically disadvantaged groups had greater caries experience and greater dental need compared to those who were more affluent, yet these were the groups that were less likely to receive appropriate care. The lower social groups living in inner-city areas are less likely to have private transport or a telephone (Rogers *et al.* 1984). If parents have difficulty keeping an appointment due to lack of transport and do not have easy access to a telephone in order to cancel the appointment, they may feel guilty enough to refrain from making further contact with the clinic. Some parents who could have taken their children to the dentist did not. This may be due to the parents feeling that 3 years of age was too young to begin dental visits.

Teenage mothers with low social class and low educational levels were less likely to use available services such as ante-natal clinics or attend the dentist themselves (King *et al.* 1983). Their children were more likely to have caries, with the child often being 4-years or more at its initial dental visit. Consequently, these young teenage mothers need to be targeted to increase their dental health awareness and to improve the dental health of their children.

As in the United Kingdom, dental care for children in Sweden is free. All 3-year-olds are offered an examination and a strong emphasis is placed on prevention with the provision of oral hygiene instruction, dietary advice and reinforcement of fluoride usage. Wendt *et al.* (1992) looked at reasons for non-attendance in preschool children in Sweden. They found that immigrant children (at least one parent not born in Sweden) had poorer attendance levels, poorer oral hygiene and higher caries rates than non-immigrants. Of the children who did not attend prior to 3-years of age, 60% had caries on initial presentation.

In Northern Ireland 68% of preschool children were caries-free, with a mean *dmft* of 1.1, although the caries levels were greater in older children (McCabe and Kinirons 1995). At 2-years of age only 35% were registered with a dentist. This figure increased to 70% at 3-years and to 75% at 4-years. There was a significantly higher caries experience in those children who were registered (dmft=1.4) than those who were not (dmft=0.54) and untreated decay comprised the greatest component. The main treatment carried out was dental extraction. Among those who were not registered, the reasons given by the parents were lack of symptoms in the child (33.6%), followed by apathy (31.6%) and fear (4.5%) on the part of the parent.

Trends indicate that the initial attendance of children is occurring at a younger age (Whittle and Whittle 1995) with a greater number attending at 2 years of age in 1994 than 4 years previously. This change was thought to be due to the success of oral health campaigns. However, the proportion of children suffering pain or undergoing a general anaesthetic for tooth removal remained similar in both 1990 and 1994. This could suggest that although parental habits and dental awareness were changing, the benefits had not yet reached the children.

1.3.8 Predictors of dental caries in preschool children

The identification of predictors of dental caries at a young age is paramount to the effective and efficient planning of dental resource and the delivery of care to those who need it. Predictors include age, social class, fluoride usage, dietary intake and microbiology of saliva.

James *et al.* (1957) showed that children given a sugared dummy had more caries than those who were not. There was a strong association between consumption of sweet, sticky foods and labial caries, particularly if given in a sweetened comforter. Around 50% of those who had sweetened comforters developed caries within the following year. The authors postulated reasons why the remaining 50% did not develop caries, which included the timing and frequency of the drinks, age at which the practice stopped and the buffering capacity of the saliva. However, they could not find a direct association between labial caries and feeding via a bottle. Winter (1988) supported these findings, adding that the use of sweetened comforters, prolonged use of medication and poor oral hygiene predisposed the child to develop caries. He further suggested that these children should be targeted before the cost of treatment increased. Children's diets are influenced by their parents, particularly the mother (Ismail 1998b). Although there has been a decrease in the use of sweetened comforters and sugar in bottles (Silver 1982, 1987, Holt *et al.* 1988, 1996, O'Brien 1994), caries in 5-year-olds is increasing, which indicates that oral hygiene and dietary practices are not improving.

Sound work by ter Pelkwijk *et al.* (1990) found DMF to be the best predictor of caries, although this had shortcomings. Screening of children at 5-6 years of age for caries produced true-positives. However, 20% of the children were not identified as caries susceptible in the screening, but developed caries at 7 years. If this predictor was relied on then some children may well have been omitted from preventive programmes. Grytten *et al.* (1988) were similarly unable to identify reliable predictors of caries in preschool children.

Holbrook *et al.* (1993, 1995) aimed to identify predictors of dental caries in Icelandic preschool children. Despite declining caries throughout the world, this is not true in Iceland, where school children receive extensive preventive measures as early as possible. These include the administration of daily mouthrinses in school and professional fluoride varnish application biannually, as well as the home use of fluoride toothpaste. In these preschool children, the most significant predictors of caries were a reduced salivary flow rate and plaque pH. In 5-year-olds, 85% had S. mutans present in the mouth, both before and after starting school. Very little change in the levels of S. mutans was observed throughout the study. However, lactobacilli levels increased from 29% preschool to 38% after starting school. The diet of the children had changed, with an increase in snacking from an average of 3.0 to 3.7 times per day, and an increase in the frequency of sugary intakes from 4.2 to 5.2 times per day. In accordance with the criteria of the study, 59% of the 5-year-olds were said to 'misuse' sugar compared to 83% of 6-year-olds. The children with no S. mutans in their mouths had significantly less dental caries.

Marques and Messer (1992) found that age, fluoride history and past dental experience were the best predictors of primary caries in preschool children. If fluoride was used in favourable quantities then low caries experience was seen. Dental caries increased as the child got older and those children who went to the dentist had more restorations than those who did not.

The most reliable caries predictors at 2-years of age for the development of caries at 4-years are poor oral hygiene, tooth morphology (deep pits and fissures) and frequency of consumption of sweet drinks (Holst *et al.* 1997b). Early identification of caries-risk children is essential in order to instigate prevention at the right time. However, even early identification and preventive measures cannot guarantee complete prevention of caries.

Grindefjord *et al.* (1993, 1995a, 1995b, 1996) investigated Swedish preschool children from 1 to 3.5 years of age in a series of longitudinal studies. The strongest predictors for caries within each age group were the presence of S. mutans and the social and ethnic background of the child. The mother's education and the frequency of consumption of sweets and sugary drinks were also strong predictors at 3.5-years (Grindefjord *et al.* 1996). Using S. mutans, caries prediction was reliable as early as one year of age, although there were 40% false-positives. When a combination of predictors was used, the reliability improved to 33%. Improved prediction of the development of dental caries by 3.5 years was achieved by assessing the child between 1.5 and 3.5 years of age rather than at one year of age. The studies showed that early caries was seen mainly on maxillary incisors, increasing from 11% of the children at 2.5 years to 37% of the children at 3.5 years. Molars were more frequently affected as the child got older. Cases with early caries showed a higher rate of progression of lesions, and these children were more likely to develop caries in the permanent dentition (Grindefjord *et al.* 1995a).

Borssén and Stecksén-Blicks (1998) found high sugar consumption at 2 years of age to be a risk factor in dental caries in preschool children. They reported that 80% of their study group ate sweets at least once a week, 25% had sweetened drinks at least once a day and 14% had night-time drinks other than water.

1.3.9 Prevention of dental caries in preschool children

The delivery of preventive and dietary advice to the mother and acclimatisation of young children to the dental environment are important factors in the prevention of dental disease. Education of parents, the profession and increased publicity of the condition in order to further educate other health care workers is paramount to the successful prevention of caries in preschool children (Davies 1998). The dentition is subject to acidic attack as soon as it erupts. Good dietary practices developed at an early age have the potential to promote a healthy dentition for life (Holt and Moynihan 1996). The dental and dietary habits of the parents, particularly the mother, influence and shape the future habits of the young child (Blinkhorn 1982). Whilst mothers are often aware of the cause of dental caries, they may be unsure of preventive measures (Hood *et al.* 1998).

Kay and Blinkhorn (1989) asked Scottish mothers for their views on prevention of dental caries using water fluoridation or a hypothetical vaccine. Although caries is a preventable disease, mothers favoured use of a no-risk vaccine to fluoridation of the water supply, despite the fact that a vaccination would be painful for the child. It was thought that their decision was influenced by the Strathclyde fluoridation case (McKechnie 1985), although if water fluoridation eliminated all caries rather than reducing it by 50% then more said they would be prepared to support it.

Another interesting observation was that mothers would accept vaccination with limited risk in preference to decreasing sucrose consumption. This reinforces the mothers' view that the dental profession has a responsibility to prevent dental caries and they would prefer the onus to be on the profession rather than themselves.

Early screening of children, perhaps at vaccination clinics, may identify those children at risk of dental caries. Increased utilisation of dental hygienists, further implementation of community water fluoridation projects and analysis of the effectiveness of other public health measures are important tools in targeting and preventing early childhood caries (Weintraub 1998).

1.3.9.1 Development of oral hygiene and dietary habits

Toothbrushing, poor oral hygiene and other habits such as nocturnal fruit juice consumption have been shown to be related to dental caries in 3-year-olds (Paunio *et al.* 1993a, 1993b, Paunio 1994). The authors confirmed that knowledge of the family's dental and dietary habits is useful when planning a preventive programme. If parents were frequent toothbrushers, then so were the children and the frequency with which the children brushed increased with age. The sugar consumption of the mother was also significantly associated with that of the child and around 50% of 1.5-year-olds were having sugar added to food and drink, with 8% receiving juice at night. The study also showed that those who consumed high levels of sugar tended to brush their teeth less frequently. The oral health knowledge of the mothers was poor, with particular regard to the use of prolonged medication. The study concluded that the personal eating habits of parents are transferred to their children. The most significant factor related to caries was the use of night-time juice, which was not associated with the social background of the child but with the fact that the mother drank fruit juice and this was readily available to the child.

Sutcliffe (1977) reported the caries experience and oral hygiene levels in 3 and 4-year-olds from deprived and non-deprived areas of Edinburgh. Scotland's cities have more areas of multiple deprivation than similar cities in England and Wales. Whilst oral cleanliness and caries experience were associated, these factors alone could not account for the very high caries experience of the children in the deprived areas. Other factors such as high and frequent sugar consumption by the children in the lower social classes may be contributory to the high caries levels.

1.3.9.2 Fluorides in the prevention of dental caries

The positive systemic and topical effects of fluoride in the prevention of dental caries are well known (Murray 1996).

Water fluoridation is a public health measure that delivers preventive care to those known to be most susceptible to dental caries, such as the lower socio-economic groups. Despite the Government's support for water fluoridation, only around 10% of the population of the United Kingdom receive water fluoridated to the optimum level of 1 part per million. Many studies have demonstrated the benefits of water fluoridation to the dental health of children (Beal and James 1971, Jackson *et al.* 1975, Rugg-Gunn *et al.* 1988, Seaman *et al.* 1989). In each case, up to a 50% decrease in the caries level of children was observed.

Newcastle was fluoridated in 1969 and non-fluoridated South Northumberland was used as a control (Carmichael *et al.* 1989). By 1987, 50% of children in Newcastle were caries-free and 16% had a *dmft* greater than 5.0 compared with 32% caries-free and 37% with a *dmft* greater than 5.0 in South Northumberland (Carmichael *et al.* 1989). One in six children in South Northumberland had undergone a general anaesthetic for dental extraction by 5-years of age. Dental abscess was more common in the children in this area. Interestingly, more children had visited the dentist in the fluoridated area than in the non-fluoridated area, in contrast to the findings of McCabe and Kinirons (1995). The consumption of sugar, as confectionery and sugary drinks, had increased in the children of both areas and a slight increase occurred in the *dmft* of the children in the fluoridated area between 1981 and 1987. This may be attributed to public complacency with regard to the detrimental effects of dietary sugars coupled with an awareness of the protective properties of fluoride. Further analysis of the data showed improvements in dental health affecting all social classes, although the level of caries in the lower social classes remained greater than that of the higher classes (Carmichael *et al.* 1989).

Stecksén-Blicks *et al.* (1989) examined 4-year-olds and found a greater proportion were caries-free (58%) compared with a study six years previously (50%). However, there were higher levels of caries (more surfaces affected) in those who did have caries, whilst the mean *dmft* for the whole group remained the same. The data also showed significant correlation between low frequency of brushing, low use of fluoride toothpaste and dental caries. Only 60% of 4-year-olds used fluoride toothpaste.

Using data from the National Diet and Nutrition Survey (Hinds and Gregory 1995), Gibson and Williams (1999) found an association between toothbrushing with a fluoride toothpaste and lower levels of caries. There was also a relationship between consumption of confectionery and higher levels of caries if the teeth were brushed less than twice a day. They supported the recommendations of the British Society of Paediatric Dentistry (BSPD 1996a) that teeth should be brushed twice daily with a fluoride toothpaste as this appears to reduce caries levels more readily than decreasing sugar consumption (Kay 1998).

The BSPD guidelines advocate the use of fluoride toothpaste as early as 6-months of age, twice daily, under direct and strict parental supervision. The results of misuse of fluoride toothpaste by young children have been highlighted (Rock 1994) and range from mild enamel opacities to marked effects on the structure and appearance of permanent teeth. Over 97% of toothpaste brands available in the United Kingdom contain fluoride and those for young children contain lower levels of fluoride than adult pastes. These should be used as part of a preventive regime. Children who do not brush their teeth as recommended can be considered as high caries-risk.

1.3.10 Management of dental caries in preschool children

The management of early childhood caries will naturally involve oral health advice and preventive techniques. Failure of these measures will result in progression of the lesions requiring invasive treatment (restorations) or, in extreme cases, dental extraction.

1.3.10.1 Choice of restorative material

With the profession and public becoming more concerned about the use of mercury, amalgam restorations are falling out of favour in paediatric dentistry. Glass ionomer cements, anterior strip crowns and preformed metal crowns are now widely used in clinical practice. In 1980, 90% of restorations in children in Western Australia were amalgam, whilst glass ionomer cements were not used. In 1994, less than 3 in 1000 restorations were amalgam, whilst 42% were glass ionomer.

Various studies have been carried out to investigate the longevity of restorative options. Roberts and Sherriff (1990) showed success rates for preformed metal crowns of 92% over 5 years. When glass ionomer restorations are compared with amalgam restorations (Walls *et al.* 1988, Welbury *et al.* 1991), amalgam has better survival rates than glass ionomer, but glass ionomer is viewed more favourably since it requires less cavity preparation and patient co-operation than placement of amalgam.

More recently, Papathanasiou *et al.* (1994) looked at survival rates of preformed crowns, amalgam and glass ionomer restorations placed by numerous operators. Their findings supported those of Roberts and Sherriff (1990), with preformed crowns having the highest 5-year survival rate (68%), compared to amalgam with survival rates of 60%. The mean survival rate of composite was 32 months, with 40% survival after 4 years. Worst of all was glass ionomer, which had a mean survival rate of 12 months and a 5-year survival rate of 5%. These findings may have been due in part to the number and varying experience of the operators.

1.3.10.2 Cost of treatment

In Australia, dental therapists carry out a larger proportion of children's treatment than dentists. They provide a more cost-effective workforce than dentists (Riordan 1997). Early childcare was originally targeted at pain relief, primarily by tooth extraction, although more restorative work is now carried out. As caries experience is declining, preventive and non-invasive techniques are becoming more commonplace than operative treatment, along with an increasing demand for orthodontic treatment. Developing third world countries are becoming more affluent and, as a consequence, caries experience is rising.

In Denmark, there is one full-time dentist per 1100 children. Costs of the provision of dental services can be reduced by longer recalls and fewer staff costs. Longer recalls benefit the children, with less time lost from school. The parents incur less expense for travel to the surgery and take less time off work. Extending the time between recalls can be instigated after careful caries risk assessment of the individuals concerned. In Norway, a trial which extended teenagers' recall times to 24 months saw little change in their dental health and reduced the cost of care (Riordan 1997).

It is acknowledged that therapists and hygienists can carry out only limited treatment, and that the dentist will have to carry out most of the more advanced treatment. In Western Australia 'remote supervision' of therapists is permissible and in Denmark dental hygienists can have their own practices. This is not so in the United Kingdom. Is there a need for the current levels of manpower if dental caries is decreasing or would more efficient use of therapists and hygienists provide a more effective service both in time and money?

1.3.10.3 Capitation

Capitation was introduced into the United Kingdom in 1988, following the completion of a 3-year trial (Coventry *et al.* 1989). The rationale behind capitation was that it should encourage dentists to use preventive measures to decrease the caries levels in the population. The trial found no evidence that capitation encouraged dentists to restore teeth or that it was more cost effective than fee-for-service. Nevertheless, capitation began in 1988.

The care of children and the effects of capitation were poignantly summarised by Curzon and Pollard (1997). Capitation led to 'supervised neglect', with children having a low filled component and a higher decayed component in their *dmft* (O'Brien 1994). Curzon and Pollard (1997) further emphasised that the profession should not leave untreated disease in a child's mouth.

1.3.10.4 Dental general anaesthesia

Dental caries may cause pain, sepsis and disturbance in sleeping and feeding patterns. In a preschool child with little previous dental experience, the management of the caries may necessitate treatment under general anaesthesia.

In 1990 guidelines were produced for the assessment of the need and safety of dental general anaesthesia (Poswillo 1990). Recommendations included the use of sedation wherever possible and these were modified and supported by the Clinical Standards Advisory Group (1995). A decrease in dental general anaesthetics was reported, perhaps not surprisingly, immediately after publication of the Poswillo report (Whittle *et al.* 1998). Specific dental practices were set up to meet the Poswillo recommendations and the figures began to increase once more, despite the decline in caries in the older age groups (O'Brien 1994). More than 230,000 anaesthetics were administered to patients under 18 years of age in England in 1994-1995 (Bridgman *et al.* 1999).

The morbidity of dental general anaesthesia has been reported (Bridgman *et al.* 1999). Symptoms were recorded in more than 90% of the children who were aged 5-15 years and who had one or more teeth extracted. These symptoms ranged from distress during induction to nightmares up to one month post-operatively.

The mortality associated with dental general anaesthesia is known to be low (Poswillo 1990). However, the administration of general anaesthesia is never without risk. In the United Kingdom, four child deaths occurred as a result of dental general anaesthesia between October 1998 and November 1999.

Dental sedation may reduce physiological and psychological stress to the patient. Inhalation sedation for children has been shown to decrease psychological stress and increase patient and parent satisfaction compared with general anaesthesia (Shaw *et al.* 1996). This study also calculated the cost of inhalation sedation to be 30% less than a hospital outpatient general anaesthesia and 57% less than a day-stay general anaesthesia.

The British Society of Paediatric Dentistry has published guidelines on inhalation sedation (BSPD 1996b) and, whilst these are only recommendations, they represent a majority view on an emotive subject. Sedation is seen as a tool that may allow treatment to be carried out without the inherent risks of general anaesthesia. Studies have shown that children referred for a general anaesthesia can often be treated successfully using sedation techniques (Crawford 1990, Blain and Hill 1998).

1.4 Dental erosion

Dental erosion is the irreversible loss of hard tooth tissue by a chemical process not involving bacteria. Erosion affects plaque-free surfaces and is therefore rarely seen at the same sites as dental caries. It is particularly prevalent on the palatal surfaces of incisors and the occlusal surfaces of molar teeth (Nunn 1996).

The aetiology of erosion can be difficult to determine. It may be caused by extrinsic, intrinsic or idiopathic factors or a combination of all three. Extrinsic factors include acidic attack from dietary or occupational sources. Intrinsic factors include gastric reflux and vomiting and idiopathic factors are those of unknown origin. Careful questioning of the individual is required to identify the cause of erosion and a recognised method of recording the severity of the erosion is advised (Lussi 1996, Grenby 1996).

The effect of dietary behaviour on erosion has been documented (Millward *et al.* 1994a, Zero 1996). Erosion occurs due to softening of enamel by acids with a pH below that of enamel dissolution (pH<5.5), although the critical level for moderate or severe erosion is said to be 4.5 (Zero 1996). Many soft drinks such as fruit juices, carbonated and non-carbonated fruit drinks have pH values of 3 to 4 and dilution according to the manufacturers' instructions has little effect on the pH value. Prolonged use of acidic drinks in comforters and bottles has been identified as a major factor in the erosion of primary maxillary incisors (Smith and Shaw 1987) and this feeding practice should be discouraged.

Intrinsic factors include regurgitation, vomiting, gastroesophageal reflux or rumination. Vomiting is the expulsion of gastric contents via the mouth, whereas the others involve a less forceful introduction of gastric acid to the mouth (Scheutzel 1996) such that the acid can be retained in the mouth and in contact with the teeth for prolonged periods. The effects of intrinsic factors are rarely seen until the condition has been occurring for 1 to 2 years. O'Sullivan *et al.* (1998) investigated the effect of prolonged gastric reflux on the primary dentition in children and did not find erosion to be as prevalent as reported in the adult population. This may be due to the children being diagnosed early and given anti-reflux medication. Eating disorders such as anorexia nervosa and bulimia nervosa are characterised by persistent vomiting. The dental effects of these psychosomatic disorders have been reported (Milosevic and Slade 1989).

Dental erosion is difficult to identify and measure (Nunn 1996). Few studies have been undertaken on this subject and the majority of those that have are of small sample size and in the adult population. In the Child Dental Health Survey in the United Kingdom in 1993 (O'Brien 1994), erosion of the primary maxillary incisors was assessed for the first time. Training for this survey proved that dentists found it difficult to agree on the interpretation of the study criteria. The greatest difficulty is in determining minimal erosion that affects enamel only. Erosion involving dentine or the pulp is easier to detect. The survey reported that more than 50% of 5-year-old children had erosion with 52% of palatal surfaces affected and only 18% of labial surfaces affected.

The National Diet and Nutrition Survey (Hinds and Gregory 1995) reported the erosive status and dietary habits of a group of 1.5 to 4.5-year-olds. Although the criteria used were the same as the Child Dental Health Survey (O'Brien 1994), the training lasted only one day rather than two and fewer written instructions were provided. Erosion was present on 19% of palatal surfaces and 10% of labial surfaces. The survey was unable to determine associations between dietary intake and the presence of erosion, although a weak association was found between consumption of sweetened and carbonated drinks and erosion.

Although maxillary incisors have been examined for survey purposes, erosion has been reported to affect primary molars and it is possible that United Kingdom surveys have underestimated the incidence of erosion in the primary dentition (Millward *et al.* 1994a, O'Sullivan *et al.* 1998).

1.4.1 Management of dental erosion

Dental erosion is managed by identifying the causal factors, providing appropriate preventive instruction and restoring tooth contour (Imfeld 1996). Intrinsic factors require the advice of a physician. Where extrinsic factors are identified then these should be eradicated.

Dietary information should be modified where appropriate (Shaw and Smith 1994). Consumption of soft drinks and acidogenic foods should be carefully monitored, kept to a minimum or substituted with a low erosive juice (Hughes *et al.* 1999). Toothbrushing should be deferred for 30 minutes after ingestion to allow the plaque pH to return to normal. Drinks should be drunk quickly and not sipped. The use of a straw is recommended. When the teeth are sensitive, close to pulpal exposure or provide poor aesthetics, restoration should be considered (Mackie and Blinkhorn 1989, Lambrechts *et al.* 1996). Restoration of primary teeth using glass ionomer cements is advisable, since they have been shown to have longer retention rates on eroded surfaces than composite materials (Powell *et al.* 1995).

1.5 Development of occlusion

Ideal or normal occlusion in the primary and permanent dentition has been described (Clinch 1951, Friel 1954). However, other studies have questioned whether it really exists (Foster and Hamilton 1968, Day and Foster 1971, Leighton 1971).

In a longitudinal study of 100 children from 2.5 to 5.5 years of age, Foster *et al.* (1972) reported a decrease in overjet and overbite and an increase in dental arch dimensions. However, despite these overall trends, some primary dentitions did not change and this individual variation made prediction of occlusal changes unrealistic. In contrast to 'normal' occlusion previously described, Foster and Hamilton (1968) found that only 3% of cases developed and edge-to-edge anterior occlusion by 5.5 years. Nevertheless, an understanding of what is expected is necessary in order to determine those conditions perceived to be outside acceptable limits.

The eruption of the primary teeth begins around six months of age and is usually complete by the age of two and a half to three years. In normal occlusion the primary dentition is spaced with the maxillary incisors and canines occluding in a labial position relative to the lowers (positive overjet), whilst posteriorly the buccal cusps of the maxillary molars overlap those of the lower molars on both sides. The upper and lower anterior teeth should occlude with the crowns of the upper incisors overlapping the lower incisors by approximately one third of the crown height (positive overbite).

Anterior open bite occurs when the upper incisors fail to overlap the incisal third of the lower incisor crowns when the mandible is brought into full occlusion (Mizrahi 1978). The cause of an anterior open bite must be determined in order to treat the condition. Non-hereditary factors are associated with the aetiology of anterior open bite (Mizrahi 1978, Turner *et al.* 1997) and these include:

1 Non-nutritive sucking habits
2 Tongue thrust
3 Trauma or pathology to the condyle
4 Neurological disturbances
5 Muscle weakness
6 Iatrogenic factors

Posterior crossbite occurs when the buccal cusps of the maxillary molars occlude inside those of the lowers.

1.5.1 Nutritive and non-nutritive sucking habits

Sucking habits in the newborn begin within a few hours of birth; indeed, reports have stated that the child may suckle within the womb (Benjamin 1967). At birth, the tongue is relatively large and the child thrusts the tongue forward to form an oral seal during normal sucking. This sucking habit is essential in order for the child to feed in its early days. The tongue eventually becomes contained within the dental arches when the eruption of the teeth takes place.

Two forms of sucking have been reported. Nutritive sucking is a means of survival helping the child to obtain essential nutrients and includes breast-feeding and bottle-feeding. Non-nutritive sucking habits include use of a dummy or digits or, in rarer cases, other items such as toys or blankets. Non-nutritive sucking is said to give the child a sense of security and a sense of comfort (Larsson and Dahlin 1985). Children whose nutritive sucking leaves them unfulfilled, such as those who are not breast fed on demand or who are bottle fed, may resort to non-nutritive sucking in order to satisfy their need (Larsson and Dahlin 1985, Turgeon-O'Brien *et al.* 1996).

1.5.1.1 Dental effects of non-nutritive sucking habits

The effects of sucking habits on the dentition are well documented (Ravn 1976). Prolonged non-nutritive sucking habits can cause anterior open bites, posterior crossbites, increased overjet and decreased overbite. In addition, the individual may develop temporomandibular joint problems, retrusion of the mandible or changes in tongue and lip posture in order to compensate for developmental discrepancies.

Disturbances in the anterior region result in an anterior open bite (Melsen *et al.* 1979). This may be an elliptical space between the incisal edges of the maxillary and mandibular incisors. The open bite establishes itself earlier in dummy suckers than digit suckers (Larsson 1994). It tends to be symmetrical when a dummy is sucked and unilateral when a digit is sucked, with the site relating to the positioning of the digit in the mouth (Comment 1992). A tongue thrust may be involved in development of an open bite in both digit and dummy suckers. Dummy sucking has more effect on posterior crossbite in the primary dentition than digit sucking (Larsson 1994). When a dummy is in a child's mouth, the teat is in the centre of the mouth and has the effect of pushing the tongue down so that the upper arch is unsupported. This, combined with the sucking action of the cheeks, is thought to contribute to a reduction in upper arch width, an increase in the lower arch width and consequently a disturbance in the posterior occlusion. Posterior disturbances manifest as unilateral or bilateral crossbites.

1.5.1.2 Prevalence of non-nutritive sucking habits

The prevalence of children's sucking habits varies throughout the world (Levine 1998). Reports give figures varying between 61% and 87% (Ravn 1974), although studies have been difficult to compare due to difference in materials and methods and the information collected.

It is accepted that digit sucking may continue in a child up to five years of age. Sucking beyond this age is termed 'prolonged digit sucking' and the effects on the occlusion may be permanent. Some children with a digit sucking habit will continue the habit until seven to eight years of age. Dummy sucking, however, tends to cease by the age of three to four years, when the child comes into contact with other children in a school or nursery environment. Due to the detrimental effect of prolonged non-nutritive sucking habits on the development of the dentition, digit sucking is a habit that should be broken early. Some workers suggest that dummies should be given to small children who have a tendency to digit suck on the pretext that the dummy habit will be broken earlier than the digit sucking habit (Baer and Lester 1987).

In a comparison of sucking habits in differing communities, Larsson and Dahlin (1985) established that 87% of Swedish children were either dummy or digit suckers compared with only 2% of African children, who were all digit suckers. The figures for the African community were similar to Scandinavian medieval skull material, where 5% of cases were digit suckers (Larsson and Dahlin 1985). Similarly, Curzon (1974) found no evidence of thumb sucking in Eskimos in the Canadian Arctic. Eskimo children spend the first three years of their lives on their mother's back with a bottle constantly in their mouths and so digit sucking is unnecessary. Obviously, the level of availability of dummies to parents and whether they choose to give a dummy to a child will affect the prevalence of dummy suckers. However it must be assumed that if a child develops a digit sucking habit, then the parents may have little effect in stopping this.

In 1979, Svedmyr reported on the prevalence and effects of dummy sucking habits on occlusion in a group of children. Of these children, 62% were dummy suckers and 14% had never been regular suckers. A high proportion of dummy suckers (60%) had some form of malocclusion, but this was true in only 16% of the non-suckers. In a study of 3-year-old children, Ravn (1974) reported a sharp decrease in the number of children using dummies as age increased, with 84% of 1-year-old children using dummies reducing to 47% at 3 years. Digit suckers, however, continued the habit for longer with 85% of those children who sucked a digit at one year continuing to do so at the age of 3 years. In this study sample, 15% of the children had not sucked other than when feeding. These findings are supported by other research. Modéer *et al.* (1982) also found fewer children to have a digit sucking habit. Digit sucking habits developed within the first few months of life with around 12% of 4-year-old children having a digit sucking habit. The number of digit suckers remained constant throughout this four-year period. The dummy sucking habit continued to develop until 1 year of age and occurred in approximately 70% of children. Between 1 and 4 years of age, the dummy sucking habit declined and by 4-years only 30% of children were still sucking a dummy.

Other workers have reported that digit sucking takes longer to disappear than the dummy habit. Larsson (1971) studied a group of 9-year-old children and found that 12% of the children were still sucking digits whilst one child still sucked a dummy. In all, 30% of the children had been digit suckers at some time, whilst 45% had been dummy suckers. Only 3% had sucked both a dummy and digit. In a further study, (Larsson 1985), the initial non-nutritive sucking habits of 9-year-olds were compared with a similar group some 14 years previously. The number of non-suckers decreased from 32% in the first study to 10% in the more recent study. There was a corresponding increase in the number of dummy suckers, possibly due to the increased availability of dummies. There was also a decrease in the number of digit suckers. Wendt *et al.* (1992) found 59% of 3-year-old children still had a sucking habit, whilst parents reported that 16% of the children had never had a sucking habit.

Nowak *et al.* (1996) studied nutritive and non-nutritive sucking patterns in young children from birth to 20 months of age. They found that 81% of the children had non-nutritive sucking habits at the age of 6 months, but this gradually declined to 59% at 20 months. If children were given a dummy, then this was the most commonly reported sucking habit with digits being sucked by around 12% of the children. As dummy habits cease at an earlier age than digit habits, it is generally accepted that the dummy habit causes less permanent damage than a prolonged digit habit. Hamada *et al.* (1998) studied dummy and digit sucking habits in Japanese children up to the age of 42 months. They used questionnaire data to investigate the length of time these habits remained with a child. Their conclusions supported those of other workers in finding that it was easier to encourage a child to give up a dummy sucking habit as opposed to a digit sucking habit. Similar work was carried out by Cerny (1981), who examined information from 600 parents regarding the day and night-time sucking habits of their children from birth to 3-years. Around 80% of the children used a non-nutritive sucking habit from birth, with 60% continuing the habit until 2 years of age and the remaining 20% still sucking digits and dummies at 3-years. Some parents (17 of 600) did not allow children to suck a dummy and 10 of these 17 children became digit suckers. Dummies were refused by 72 children and 38 of these became digit suckers. Therefore, parents should encourage dummy sucking if the child appears to favour digit sucking since a dummy sucking habit is an easier habit to break. Interestingly, 56 of the children who either refused a dummy (72) or were not given one (17) became digit suckers.

Farsi and Salama (1997) reported on the sucking habits of Saudi Arabian children and their influence on the primary dentition. Their study involved almost 600 children aged between 3 and 5 years of age. The prevalence of sucking habits was 48% and the majority of these children used a dummy rather than a digit. In keeping with the findings of other studies, many of the dummy suckers had stopped the habit by 5-years whereas the digit suckers continued with their habit.

1.5.1.3 Social factors and non-nutritive sucking habits

Social background influences the prevalence of non-nutritive sucking habits. Calisti *et al.* (1960) found that children in a high socio-economic group had a higher prevalence of digit sucking than children in lower or middle socio-economic groups. Similarly, Infante (1976) reported children in higher social groups who lived in large populations (>2500) had a greater prevalence of thumb sucking than children in lower groups living in smaller communities.

Children's non-nutritive sucking habits are influenced by their surroundings. Zadik *et al.* (1977) examined three groups of children. Some of the children were living in a city and others in a kibbutz. Two of the groups of children within the kibbutz attended nursery. One group were given dummies on demand, whilst the other group were not given dummies on the recommendations of the nursery staff. The children who lived in the city were allowed to have dummies if they wished. In the groups where dummies were available, more than 70% of the children used them. However, it was the city children who had the highest incidence of sucking, with 95% of the group using a dummy. Very few of the children in the study had both digit and dummy habits and, in the group that had no dummies, a greater percentage of the children sucked their fingers than in the other two groups. This study suggests that the children who were allowed to suck a dummy would in many cases not suck a digit.

Paunio *et al.* (1993b) studied the effects of the living conditions and social background of 3-year-old children on the use of digit and dummy sucking habits. They found that dummy use at this age was due in part to the parent using the dummy as a comforter to calm the children if they were distressed. They also found dummy sucking to be associated with poor levels of oral hygiene.

1.5.1.4 Effects of prolonged non-nutritive sucking habits

i. Anterior occlusion

Contrary to the reports of other workers, Taft (1966), using cephalometric analysis, demonstrated that thumb sucking did not adversely affect growth, nor did it cause lingual inclination of the lower anterior teeth or proclination of the upper anterior teeth. In a longitudinal study of the effects of digit and dummy sucking, Bowden (1966) found that both dummy and digit suckers showed an increased incidence of anterior open bite than those children who did not suck. He also found that the children who had a prolonged digit sucking habit had a greater incidence of open bite than those who used a dummy, possibly because the dummy habit had been given up at an earlier age. Children with a prolonged digit sucking habit also had an increased incidence of anomalies of dentofacial relationships and tongue thrust tendencies. Those who had discontinued the sucking habit at an earlier age had lower frequencies of these anomalies. These findings have been supported by others (Johnson and Larson 1993).

Moore *et al.* (1972) looked at the effects of prolonged digit sucking on the facial growth of monkeys. They found that prolonged sucking affected the anterior face height by creating an anterior open bite that corresponded with the digit habit. When the digit sucking ceased, the open bite closed. Superimposition of the growth pattern suggested a downward and backward rotation of the maxilla, resulting in closure of the open bite. Although digit sucking has the action of proclining the teeth, the resulting protrusion does not in fact inhibit the eruption of these teeth but leads to a reduced vertical growth of the anterior alveolar process (Larsson and Ronnerman 1981). Children who cease the sucking habit during active growth may therefore benefit from spontaneous correction of the anterior open bite unlike those who continue to suck until an older age. In a review of the literature of digit sucking, Brenchley (1991) concluded that there was evidence to suggest that the skeletal pattern could be influenced in the growing child by digit sucking, and that discouragement of such a habit might alleviate detrimental effects.

Melsen *et al.* (1979) reported on the effect of sucking habits on the prevalence of malocclusion and on the swallowing patterns of 725 Danish children aged 10 to 11-years. Parents were asked whether the child had sucked a thumb, finger, or used a dummy. Clinically, it was noted whether the child swallowed normally, had a tongue thrust, or kept the teeth apart when swallowing. In keeping with other studies, they found that digit sucking was related to a higher frequency of open bite. However, they also found that the incidence of crossbite was higher in the sucking groups than in the non-sucking groups. Their findings suggested that although a dummy may be preferable to a finger sucking habit, in that the habit can often be broken earlier, both sucking habits tend to have an influence on the swallowing and possible tongue thrust mechanism. Of the children in this study group, 78% had used a dummy, 8% had used a digit, and 14% had no history of non-nutritive sucking habits.

These figures are similar to the findings of other studies (Ravn 1974). Svedmyr (1979) found dummy sucking to be the most common cause of anterior open bite, with protrusion of the teeth being more common in digit suckers. Larsson (1986) also found that open bite was almost always associated with prolonged dummy sucking although, as the habit usually ceased by 4 years of age, no detrimental effects were reported in the permanent dentition. Children who sucked until puberty also had spontaneous correction of open bite, but those who sucked beyond the pubertal growth spurt did not (Larsson 1994).

Ravn (1976) examined three hundred 3-year-old children and linked their sucking habits with the occlusion in the canine and molar region and also with the anterior occlusion. The study found that fewer children who were dummy suckers had an open bite than those who were digit suckers, although anterior open bite was more pronounced in children who were persistent dummy suckers than those who sucked digits. Many of the digit suckers were still sucking, whereas those who had sucked a dummy had given up the habit by this time. Where children were reported to have sucked until the age of 2 years, many of the open bites had closed over the 12 months leading up to the third birthday. Children who were persistent suckers tended to have an increased overjet, in some cases exceeding 6 mm. When these suckers were divided into digit and dummy suckers, it was apparent that although the majority of digit suckers did not have an increased overjet, those who did, tended to have an extreme overjet. This is probably related to the positioning of the digits in the mouth.

Fukuta *et al.* (1996) reported on the effect of digit sucking on the primary dentition. They looked at the incidence of increased overjet and decreased overbite in a sucking group and compared it to a control group with no sucking habits. They found that 20% of the children who were 3 to 5 years of age had a digit sucking habit. They also found that open bite and increased overjet were more common in the digit sucking group than in the non-sucking group. The effects of digit sucking could be seen as early as 3 years of age. Their findings supported the work of others, suggesting that digit sucking should be eliminated at an early age. Farsi and Salama (1997) found that an increased overjet and open bite were more prevalent in children who sucked digits than those who did not. However, the differences were more significant when dummy suckers were compared with non-suckers. Children with a prolonged sucking habit were more likely to have an affected overjet and open bite.

ii. Posterior occlusion

Bowden (1966) found that the molar occlusion of children with a history of dummy and digit sucking did not change significantly between 2 years and 8 years of age. However, there was a tendency for any change to be associated with the side on which the digit was sucked. The incidence of posterior crossbites was similar in those children who sucked and those who did not. Kisling and Krebs (1976) looked at the occlusion of 3-year-old Danish children. In their study group, they found a high number of dummy suckers, particularly in the group with a posterior crossbite.

Kutin and Hawes (1969) reported on posterior crossbite in the primary dentition. Their study examined crossbite in children aged 3 to 5 years. A further group of children was examined (aged 7 to 9 years) in order to observe the eruption of the first molars. They found that in both age groups, around 8% had some form of posterior crossbite. They suggested that posterior crossbite is not self-correcting and a posterior crossbite in the primary dentition is almost always followed by a crossbite in the next dentition.

Despite this, Ravn (1976) was unable to demonstrate a significant difference between the posterior occlusion of sucking groups, although he noted that there was a lower percentage of normal or ideal occlusion in those children who sucked digits. Ravn (1976) concluded that if a sucking habit persisted for three years or more then a posterior crossbite would develop.

Svedmyr (1979) found that posterior crossbite was more common in dummy suckers than in digit suckers. A posterior crossbite associated with dummy sucking may develop as early as 2 years of age and persist after the habit has ceased. This is in contrast to open bite which corrects itself once the sucking habit has ceased. Svedmyr recommended that dummy sucking should cease once the child is 1 year old in order to avoid detrimental effects on the occlusion.

When Modéer *et al.* (1982) examined five hundred and eighty eight 4-year-old children, 15% had a unilateral posterior crossbite, 2% had bilateral crossbites and 5% had a cusp-to-cusp occlusion. The incidence of unilateral crossbite was greater among the dummy suckers than the digit suckers, although the difference was not statistically significant even when the length of time of sucking was taken into consideration. The unilateral crossbite was more often found on the right and in girls rather than boys.

Lindner and Modéer (1989) reported on the relationship between the sucking habits of 4-year-old children and unilateral posterior crossbite. Their study clearly showed that a prolonged sucking habit reduced the maxillary arch width, producing a unilateral posterior crossbite. They found that dummy sucking had a more significant effect than digit sucking and this was particularly noticeable in the canine region. All 76 children in the study had a history of sucking at some time from birth and 63% of them still had a sucking habit at the age of four.

In a study of posterior crossbites in Norwegian and Swedish 13- and 14-year-old children, Øgaard *et al.* (1994) found that non-suckers had a low prevalence of posterior crossbite. Children with a history of digit sucking had a higher prevalence of crossbite than non-suckers, but a lower prevalence than dummy suckers. They found that dummy sucking decreased the inter-canine arch width in the maxilla and increased the inter-canine width in the mandible. Dummy sucking had to have occurred for at least two years to affect the maxilla and three years to affect the mandible to any significant degree. The main conclusion of this study was that finger sucking does affect the development of the posterior crossbite, but to a lesser degree than the dummy sucking habit.

Lindsten *et al.* (1996) were unable to demonstrate an association between the length of time children sucked a dummy and the development of crossbite. However, their study was based on a 15-minute video and parental report of whether the child sucked at night. Although not all children sucked the dummy during the video, all of the children sucked a dummy whilst going to sleep and this appeared to be the most important time for dummy use in these 3-year-old children. A further study of primary molar relationships involved 680 children between 2 and 6 years of age (Infante 1975). Digit sucking was found to be strongly associated with the development of a posterior crossbite. They also found that posterior crossbite was greater in children of both middle and lower socio-economic status and was more common in girls than in boys. Farsi and Salama (1997) similarly found no significant difference between the posterior crossbite in suckers and non-suckers.

1.5.1.5 Use of orthodontic and conventional dummies

The appearance and design of pacifiers or dummies have changed over the last 50 years. An orthodontic dummy is said to resemble the mother's nipple and is thought to have fewer detrimental effects on the developing occlusion. Adair *et al.* (1992, 1995) looked at the effects of orthodontic and conventional dummies on the developing dentition of children aged two to five. Both studies compared children who were divided into a control (non-sucking) group, a group who sucked an orthodontic dummy and a third group who sucked a conventional dummy. The children with a prolonged dummy habit tended to have an increased overjet, anterior open bite and posterior crossbite. The studies found a significant difference between the occurrence of an open bite in those children who sucked and those who did not. There was no significant difference between the occlusal effects of sucking a conventional dummy compared with an orthodontic dummy. Those who sucked an orthodontic dummy did have a tendency toward a larger overjet than those in the conventional dummy sucking group. The studies concluded that there was little or no advantage in using an orthodontic dummy.

1.5.1.6 Non-nutritive sucking habits and dental caries

In addition to the detrimental effects of dummy and digit sucking on the developing occlusion, Winter (1980) also demonstrated an increased caries risk, particularly with the use of sweetened comforters or dummies dipped in honey or other sugar-containing substances. The development of nursing caries due to the use of sweetened comforters is a particularly serious condition as extensive dental treatment may be required. Malocclusion may correct itself spontaneously once the habit is stopped.

Ollila *et al.* (1998) reported an increased caries-risk in 1 to 4-year-old children with a prolonged dummy sucking and nocturnal bottle-feeding habit. Their study of 166 children was based on colonisation of the children with candida and lactobacilli, due to the use of the dummy or bottle. Both habits increased the likelihood of the children becoming colonised with candida or lactobacilli. As lactobacilli is identified as a predictor for the development of dental caries, both the dummy and bottle habits are risk factors for children in this age group. Interestingly, the prolonged use of a dummy was shown to be a higher risk factor than the use of a nursing bottle at night.

1.6 Summary

In the Western world, the improvement in dental health in preschool and 5-year-old children appears to be slowing down, with a slight increase in *dmft* reported in the last Child Dental Health Survey (O'Brien 1994). Similar trends have been seen elsewhere (Stecksén-Blicks and Holm 1995).

The amount and frequency of sugar consumed as between-meal snacks amongst 11-year-old children throughout Europe remains high (Kuusela *et al.* 1999), probably as a result of dietary habits instilled at a young age (Blinkhorn 1982). The influence of dietary sugar has been modified by the increased availability of fluoride in water and dental products. In some areas a direct relationship between sucrose consumption and dental caries can no longer be demonstrated (Cleaton-Jones *et al.* 1984, Marques and Messer 1992). However, the effects of poor oral hygiene and dietary habits are well documented and the sequelae of dental caries can be far-reaching, with the risks of dental general anaesthesia ever real.

Although the aetiology of dental erosion may be diverse, the excessive consumption of acidogenic foods and drinks is the most common cause. It is well documented that children in the United Kingdom consume fruit drinks from a young age and that use of sweetened comforters continues (Holt 1991, Hinds and Gregory 1995). The prevalence of primary incisor erosion has been recorded (O'Brien 1994, Hinds and Gregory 1995) and evidence suggests that, unlike dental caries, it is not necessarily more prevalent in the lower socio-economic groups (Millward *et al.* 1994b). It is essential that young children at risk of developing erosion are identified and preventive measures taken, since the long term management of erosion in the permanent dentition may involve extensive and advanced restorative procedures (Nohl *et al.* 1997).

Non-nutritive sucking habits have been shown to establish themselves in children with unfulfilled nutritive needs (Johnson and Larson 1993). There is a rapid increase during the first year of life and a gradual decline over the following years, with dummy sucking ceasing at an earlier age than digit sucking (Modéer *et al.* 1982). The effects of sucking on the primary dentition have been well documented. Whilst dummy sucking has a more profound and rapid influence on the developing primary occlusion, the habit tends to cease earlier than digit sucking. It is prolonged digit sucking which may have long-term effects on the occlusion of the permanent dentition.

Much of the information available regarding the dental status of preschool children has been gained via cross-sectional studies. These fail to present a true picture of trends within a population. Longitudinal studies provide a more accurate representation, although the logistics of organising and funding such a venture are often prohibitive. As well as manpower, it is essential to motivate the study population to maintain their commitment over a prolonged period of time.

Aims of the Study

The purpose of this study was to examine the influence of external factors on the development of dental caries, occlusion and erosion in a group of preschool children.

Specific objectives

1 To develop a training programme for non-dental health care professionals enabling them to identify dental caries, stages of occlusal development and the presence of dental erosion to an acceptable level.

2 To determine the longitudinal changes in the caries experience of a group of preschool children at 31-, 43- and 61-months of age.

3 To determine whether social background and dietary habits influenced the change in caries experience of this group of children.

4 To determine the longitudinal changes in the occlusal development of the same group of children.

5 To determine whether non-nutritive sucking habits influenced the changes in occlusal development within this group of children.

6 To determine the dental erosion experience of the children at 61-months of age.

7 To investigate the influence of the consumption of fruit drinks on the presence of dental erosion in this group of children.

CHAPTER 2

MATERIALS AND METHODS

2.1 Background to the study

In consequence of a meeting convened by WHO (Europe) in July 1985 in Moscow, a decision was made to design and develop a longitudinal survey strategy that could be used to determine the current problems in child health and development and how they may be prevented. On the basis of this, a multicentre study was designed, the European Longitudinal Study of Pregnancy & Childhood (ELSPAC). The Avon Longitudinal Study of Pregnancy & Childhood (ALSPAC) has built onto, and substantially extended, the European project.

Now known as the Avon Longitudinal Study of Parents and Children, ALSPAC has the overall aim of identifying ways in which to optimise the health and development of children (ALSPAC Study Team 2000). The main aim is to understand the ways in which the physical and social environment interact, over time, with the genetic inheritance to affect the child's health, behaviour and development. By understanding the causal pathways to diseases and disorders, preventive interventions can be devised for future testing. Conditions include those that are increasing rapidly over time or affect large numbers of the population.

The study is designed to link together information from a variety of sources including hands-on examination of the children, questionnaires completed by parents, health records, assays of biological samples and specific measurements of the environment in the home. These unique data will be used to test hypotheses on the causes and prevention of childhood ailments and disorders. Prospective data from early pregnancy and from maternal as well as child DNA permit transgenerational studies.

The policy is to collaborate closely with outstanding scientists in different fields. There is a distinguished Scientific Advisory Committee and Genetic Advisory Committee and these are advised by the ALSPAC Ethics and Law Committee, which reports to three district Medical Ethics Committees within the Avon study area. Uniquely the study is supported both financially and scientifically by the University of Bristol. In 1998 the ALSPAC study was given the status of an MRC Cooperative Group.

2.1.1 ALSPAC study group

The ALSPAC study is designed to monitor factors affecting the health and development of a population-based cohort of 14200 mothers and their offspring. Mothers were invited to join the study if they had a pregnancy with an expected date of delivery between 1st April 1991 and 31st December 1992. They also had to be resident in the three Bristol-based health districts of Avon. The area included the city of Bristol, surrounding rural areas, Weston-Super-Mare, Clevedon, Portishead and the industrial surrounds of Avonmouth.

Mothers completed questionnaires during their pregnancy which related to various aspects of their social and environmental background (including their occupation history), their medical history, details of diet and history of previous pregnancies.

Since the birth of their children, mothers have completed questionnaires at regular intervals and the children continue to be monitored via this questionnaire data. From 7 years of age, the children will be invited to attend a clinic held annually, where various aspects of their general development will be examined.

The ALSPAC study has attracted significant peer-reviewed grant support and has the potential to provide a wealth of longitudinal information on these children for the foreseeable future.

2.1.2 Children in Focus

A 10% cohort of ALSPAC children (a maximum of 1400 children) is known as Children in Focus (CIF).

The aim of Children in Focus was to examine the children in a way that cannot be done using questionnaires to their parents. The sample provides both a validation for certain aspects of the self-completion questionnaires and an answer to some important questions. These are related, for example, to the ways in which childhood diet, growth, anaemia, otitis media with effusion, visual defects, parenting skills and early cognition are related to the development of intellectual competence, speech and language as well as motor development of the child.

These 1400 children born within ALSPAC criteria were monitored periodically via further extensive questionnaires and clinic visits. These children were randomly selected from the ALSPAC births between 6th June and 11th

December 1992. Excluded were those mothers who had moved away from Avon or were 'lost to follow up' when they moved without forwarding addresses, those who had refused to participate or fill in questionnaires, and those whose baby had died or who had two or more pregnancies in the study. The cohort also excluded premature babies born at less than 33 weeks gestation, who were recruited to the Avon Premature Infant Project (APIP). There was no selection on place of residence as long as it was within the study area at the time of the first invitation to join Children in Focus. Children who moved away were still invited to participate, although travel costs were unable to be met in full.

Prior to the present study, the CIF had attended clinics at 4-, 8-, 12-, 18- and 25-months of age where they were assessed regarding various aspects of development. These clinic visits were carefully planned and great emphasis was placed on maintaining the cohort (Appendix 1.1).

Dental data were collected when the CIF were 31-, 43- and 61-months of age. These ages were not selected intentionally, but were time-points offered to the author by the ALSPAC and CIF study director (Professor Jean Golding).

Since efforts to obtain funding for the dental study were unsuccessful, it was fortunate that preparations were able to proceed. However, this resulted in the initial study being set up within a short time frame (six weeks) and influenced the decision to use non-dental staff for data collection (Section 2.4).

The number of parents and their children attending the clinics varied (Table 2.1) and failure to attend was due to loss of contact with the mother, unavailability at that time or death of either the mother or child.

Table 2.1: Attendance levels

	Invited	Attended	Male	Dental records available
31-month clinic	1305	1135 (87%)	620 (54.6%)	1102
43-month clinic	1249	1065 (85%)	590 (55.5%)	1063
61-month clinic	N/A	994	542 (54.6%)	992

N/A: Not available

Of the children invited to the clinics, 1208 dental records are held and these include those of the 867 children who attended all three clinics. The discrepancy between the number of children attending the clinics and the dental records available can be attributed to non-compliance of the child or to errors in data collection (Section 2.7). The attendance pattern of the mothers was analysed for the 18-month CIF clinic and children were more likely to attend if their mothers were 25-years-old or more at delivery and if they had been educated beyond O-level standard. If this trend continues then there will be an element of bias in the sample of the CIF who attend. However, this bias is unlikely to be important in longitudinal analyses since the trend will be common to each of the clinics. Further details of the number of children invited and subsequently seen at the CIF clinics, the bias of the sample and the representative nature of the sample are in Appendix 1.2.

2.2 Subject confidentiality

Strict subject confidentiality was observed throughout the ALSPAC and CIF studies. Each mother was issued with an identification number (mother ID), which is used to link all information gained from questionnaires or from clinic visits.

The CIF were given a new identification number for each clinic (clinic ID). Each clinic ID comprised nine digits and a letter (e.g. 503113417A), as explained in Table 2.2.

Table 2.2: Composition of CIF identification number

Characters	Description	Definition
First 2 digits	Clinic ID	50 = 31-month 58 = 43-month 74 = 61-month
Following 5 digits	Child's study ID	Specific to each clinic
Last 2 digits	Checksum	Calculated from child's study ID to prevent errors when keying data into data base
Suffix 1 letter	Twin code	A = singleton, or first born of multiple births B = second born C = third born

When the data were analysed, the child's clinic ID was replaced with the mother's ID in order that:

i The clinic data could be linked to the questionnaire data

ii Staff were unable to identify a child and its mother by name, since they had access to mother or child ID but not both. ALSPAC confidentiality forbids both ID numbers to be held in the same database.

2.3 Compilation of Questionnaires

In addition to the clinical data collected at the CIF clinics, the parents or carers were asked to complete questionnaires regarding the development of the child, at regular intervals (Appendix 1.3).

Due to the multidisciplinary nature of the ALSPAC study, each questionnaire addressed a wide range of subject areas. Collaborators submitted questions to the ALPAC and CIF Study Director for approval. The time scale required to compile and print each questionnaire meant that the questions used to compare with the dental data had been finalised some time before the dental study began. Therefore, whilst it is acknowledged that some questions lack the detail pertinent to dental disease and development, the replies available were utilised in as appropriate a manner as possible.

This study used data collected when the children were 6-, 15-, 24- and 36-months old. The data contained information about dietary (including drinking) habits and digit and dummy sucking habits of the child (Appendix 1.3).

Data were available concerning the social background of the mother including home ownership status, maternal age at delivery and the level of maternal education. This information was used in preference to the Registrar General's Classification of Occupations, which fails to classify families where there is a single parent or where the father is unemployed.

This information was compared with the dental caries and dental erosion data collected at the CIF clinics held when the children were 31-, 43- and 61-months.

2.3.1 Completion of questionnaires and data entry

Mothers who had difficulty completing questionnaires, either due to time management or an inability to read or write, were offered help. A designated member of the ALSPAC study team would visit the home at a pre-arranged time.

Questionnaire data were keyed into a database by staff members employed by the ALSPAC study.

2.4 Examiners

The dentally-qualified trainer (the author) produced the study criteria and verified the reproducibility of the data. The trainer remained the same throughout the study. The examiners were non-dental personnel (Table 2.3) whose availability differed between clinics (Table 2.4). When the examiners were unavailable, the trainer examined the children.

Only two examiners were used for the 61-month data collection. This was due to the lack of availability of previous examiners and the impracticality of training new staff. When the children were 61-months, the assessment of dental erosion was required in addition to the data collected previously. Because the two examiners had collected data at 31- and 43-months, the training programme concentrated on introducing the criteria for the identification of dental erosion.

The trainer collected data when the examiners were unavailable. The number of children seen by each examiner and the trainer at each age is in Appendix 1.4.

Table 2.3: Professional background of trainer and examiners

	Professional background	Qualifications
Trainer	Dentist	BDS, LDSRCS, MSc
Examiner 1	Nursery nurse (Special Care Baby Unit)	NNEB
Examiner 2	Registered nurse and health visitor	RGN
Examiner 3	Registered nurse and health visitor	SRN, SCM, HV Certificate
Examiner 4	Registered nurse (Special Care Baby Unit)	SRN, Midwife
Examiner 5	Registered nurse and health visitor	SRN, HV Certificate
Examiner 6	Previous reception experience at CIF clinics	Previous reception experience
Examiner 7	Psychology postgraduate involved with Children Otitis Media with Effusion Trial (COMET)	BSc Psychology
Examiner 8	Registered nurse	SRN, Midwife
Examiner 9	Registered nurse	RGN

Table 2.4: Staffing levels of the clinics

	Trainer	Examiners 1	2	3	4	5	6	7	8	9
31-month clinic	✓	✓	✓	✓	✓	✓	✓			
43-month clinic	✓	✓	✓	✓				✓	✓	✓
61-month clinic	✓	✓	✓							

2.5 Study variables (Examination)

2.5.1 Teeth

Throughout the study, all of the dental features for each patient were coded for ease of recording the data, to ensure that the parent was unaware of their child's dental condition, for purposes of quantification of the results and for statistical analysis.

Any variables that could not be determined were coded Q. The use of this code reflected difficulties in the examination and the lack of familiarity that the examiners had with regard to the diagnosis of certain pathological conditions.

2.5.1.1 Tooth identification

The examiners identified the teeth using the FDI 2-digit system (Appendix 2.1); this was modified for the 61-month study in order to include the permanent first molars and incisors (Appendix 2.2). The modification was introduced to limit the amount of new information for the examiners. The examination began in the upper right quadrant with the last tooth in the arch (usually the second primary molar, 55) and followed a clockwise direction around the mouth, i.e. upper right to left, then lower left to right.

2.5.1.2 Caries identification

In accordance with the criteria laid down by the British Association for the Study of Community Dentistry (BASCD), the presence of caries was made by visual means only; probes and radiographs were not used and only overt cavitation was recorded. Examiners identified the specific tooth using the tooth code and then recorded the caries using a caries code (e.g. 75 C1) as in Table 2.5.

Table 2.5: Quantification of caries

Variable	Caries code	Criteria for code
Tooth code...	No code	No caries visible
Tooth code...	C1	One carious surface
Tooth code...	C2	Two carious surfaces
Tooth code...	C3	More than two carious surfaces

2.5.1.3 Restorations

Restorations were recorded in a similar manner to caries. The tooth was identified using the tooth code and the restoration recorded using a restoration code (e.g. 65 F2) as in Table 2.6.

Table 2.6: Quantification of restorations

Variable	Restoration code	Criteria for code
Tooth code…	No code	No restorations visible
Tooth code…	F1	One surface restoration
Tooth code…	F2	Two surface restoration
Tooth code…	F3	More than two surface restoration

Examiners were aware of the different restorative materials that could have been used. If a tooth had a filling and a restoration, this was given both codes (e.g. 65 C1 F1). However, due to their limited dental knowledge, the examiners were not expected to identify secondary caries or failed restorations.

2.5.1.4 Anomalies of teeth and soft tissues

i Supernumerary teeth

Supernumerary teeth were coded as 9 and were identified in the position in which they appeared in the arch.

ii Absent teeth

If teeth were not present, then the tooth identification code was omitted. If the parent gave the examiner a reason for the tooth's absence, then this was recorded as an additional comment. The trainer translated the tooth absence in terms of extracted (X) or lost due to trauma (T); if not, then the tooth was categorised as A – absent. Similarly, congenitally absent teeth were reported by some parents and these were also coded as A. Teeth reported as unerupted were coded U and partially erupted as P.

iii Fused or double teeth

A number of teeth were reported as being fused or double teeth and these were recorded in the 'examiner comment' section in the database.

iv Discoloured teeth

Discoloured teeth were recorded with the code D. Examiners identified anterior teeth with intrinsic discoloration, which was typically seen as a consequence of traumatic injury.

v Abscessed teeth

Examiners recorded abscesses using the code GB. The abscess code followed the tooth code or any other tooth-related codes such as those associated with traumatised (discoloured) teeth, grossly carious and heavily restored teeth.

vi Tongue-tie

The child was asked to protrude the tongue. The examiner coded the tongue as in Table 2.7.

Table 2.7: Tongue (T)

Variable	Code	Criteria for code
T	Y	Child can protrude the tip of the tongue No tongue-tie present
T	N	Child cannot protrude the tongue Tongue-tie present
T	Q	Unable to categorise

2.5.2 Arch form

With the mouth open, the examiners assessed the position and alignment of the anterior teeth in both arches. The upper labial segment (U) and lower labial segment (L) comprised the four incisor teeth and were assessed for tooth alignment, crowding, spacing and the presence of a median diastema (Table 2.8).

Table 2.8: Upper labial segment (U) and lower labial segment (L)

Variable	Code	Criteria for code
U/L	K	Well-aligned
U/L	C	Crowded
U/L	S	Spaced
U/L	M	Median diastema
U/L	Q	Unable to categorise

2.5.3 Occlusion

2.5.3.1 Anterior occlusion

The teeth were observed in centric occlusion and the relationship of the upper and lower labial segments (AOB) was recorded using the codes in Table 2.9. The position of the upper labial segment relative to the lower labial segment was recorded (ROJ).

Table 2.9: Anterior occlusion

Variable	Code	Criteria for code
AOB	N	Positive overbite or edge-to-edge incisor relationship
AOB	SYM	Symmetrical anterior open bite
AOB	R	Anterior open bite exaggerated on the right
AOB	L	Anterior open bite exaggerated on left
AOB	Q	Unable to categorise
ROJ	N	Positive overjet
ROJ	Y	Reverse overjet
ROJ	Q	Unable to categorise

2.5.3.2 Posterior occlusion

With the teeth still in centric occlusion, the examiner recorded the posterior occlusion (X) on the right (XR) and on the left (XL). The codes used are in Table 2.10.

Table 2.10: Posterior occlusion

Variable	Code	Criteria for code
XR	N	No crossbite present or buccal cusps meet in an edge-to-edge occlusion
XR	Y	Upper and lower right molars in crossbite
XR	Q	Unable to categorise
XL	N	No crossbite present or buccal cusps meet in an edge-to-edge occlusion
XL	Y	Upper and lower left molars in crossbite
XL	Q	Unable to categorise

2.5.4 Erosion

At the 61-month clinic, the number of study variables was increased to include dental erosion. The teeth examined for erosion were the upper primary incisors and the lower primary first molars. The examiner looked at the labial and palatal surfaces of the incisors and the occlusal surfaces of the first molars and assessed the depth of the erosion and the surface area affected, using pre-determined criteria (Table 2.11). Erosion was coded as 9 for depth and area if the tooth was absent, carious or restored.

Table 2.11: Quantification of erosion

Depth of erosion	Surface area affected by erosion
0 No tooth loss	0 No tooth loss
1 Enamel loss only	1 Less than 1/3 of surface area involved
2 Enamel and dentine loss	2 1/3-2/3 of surface area involved
3 Enamel and dentine loss extending into pulp	3 More than 2/3 surface area involved
9 Unable to categorise	9 Unable to categorise

2.6 Training the examiners

At the beginning of the study, none of the examiners had previous experience of undertaking dental examinations.

The aims of training staff for the 31- and 43-month clinics were:

1 To familiarise each examiner with the identification of the primary dentition using the FDI 2-digit index (Section 2.5.1.1).

2 To enable examiners to identify and code the study variables using pre-determined criteria (Section 2.5).

The 61-month study introduced additional variables for dental erosion. The two examiners in this study had collected data at the 31- and 43-month clinics and, therefore, the aims of the 61-month training programme were:

1 To introduce the early mixed dentition using a modification of the FDI index (Section 2.5.1.1).

2 To introduce each examiner to the manifestations of dental erosion in the primary dentition (Section 2.5.4).

2.6.1 Training sessions

The training programme for the 31- and 43-month clinics involved sixteen hours of training over six tutorial sessions. A further 1-hour involved a mock clinic that took place prior to the first official clinic at each stage.

Eleven hours of training were provided for the 61-month clinic in the form of three 3-hour tutorial sessions and two 1-hour practical sessions (a mock clinic and a school visit). This programme also included a revision session using the original training materials.

The training aids were available to all staff for use at times other than the official training sessions.

2.6.2 Training materials

2.6.2.1 Models

Plaster-cast models of the complete primary dentition in normal occlusion were issued (Appendix 2.3). The models were used to identify incisor, canine and molar teeth, to demonstrate the FDI index and to explain normal arch form and occlusion.

Seven articulated acrylic models were produced (Appendix 2.4) which showed a sound dentition and variations in tooth number, arch form and occlusion.

A further ten articulated acrylic models were produced which showed the above variables with the addition of carious, abscessed and discoloured teeth (Appendix 2.5).

The trainer produced a checklist for each model (Appendix 2.6), which the examiners could use as a self-assessment exercise at any time throughout the training and study periods.

2.6.2.2 Paperwork

A handout (Appendix 2.7) provided a guide to tooth identification, the FDI index, dental terminology for features of arch form and occlusion, the codes for each study variable and the order in which the variables should be examined. The handout was used for training in the 31- and 43-month programmes and as a revision aid for the 61-month programme.

For the 61-month training sessions the examiners were introduced to dental erosion and the new study variables using a further handout (Appendix 2.8). It stated the teeth and surfaces to be examined, the codes to be used and the text of a commentary that accompanied a sequence of colour-slides used for training purposes.

2.6.2.3 Colour photographs and slides of clinical cases

For the 31-, 43- and 61-month training programme, a selection of photographs was available to demonstrate study variables that were difficult to depict on models (Appendix 2.9). In addition, a sequence of colour-slides of clinical cases (Appendix 2.10) was shown and discussed.

For the 61-month training programme, a colour-slide sequence (Appendix 2.11) demonstrated the appearance of dental erosion, the teeth to be examined, the study variables and the relevant codes.

2.6.2.4 Extracted primary teeth

A selection of extracted primary teeth was used to familiarise the examiners with a 3-dimensional image of overt cavitation, restorations and sound teeth. These were discussed on a one-to-one basis with the trainer.

2.6.3 Examination practice

Before the first CIF clinic for each age group, a mock clinic took place which involved reviewing all of the planned observations (e.g. teeth, ears, eyes etc) and checking the timing of the clinic with regard to patient numbers. These children were those of staff members and, therefore, were not true representations of the CIF. The children who attended the mock clinic prior to the 61-month clinic had no dental erosion. Therefore, children in the reception class of a local school were examined in order to increase the examiners' experience of detecting dental erosion.

2.7 Clinical data collection

At each CIF clinic, the number and type of observations varied (Appendix 3.1). For example, in the 31- and 43- month clinics, the dental examination followed a tympanometry test, which often unsettled the children. Therefore, the dental examination was undertaken with care and, if the child was distressed, the examination was abandoned.

Whilst the order of the observations also changed at the 61-month clinic, the children were familiar with the dental observation by this stage and no problems were encountered.

The dental data were recorded on mini-cassette tapes using a foot-operated dictaphone machine and then transferred to a form in the database at a later stage (Appendix 3.2). A pro forma based on the form was available for data collection in the event of a technical fault with the machine (Appendix 3.3). To ensure that the data were correctly identified, the examiner used one side of tape per child and recorded the examiner's name, the date and the child's clinic ID at the beginning of the tape. The examiner stuck a label bearing the child's clinic ID on the correct side of the tape and wrote the date and child's ID on each storage box of twenty data records. This occurred before the examination but in front of the mother and child to ensure that the correct label was put on to the appropriate tape and to introduce the child to the dictaphone machine.

Data were not collected when the child was non-compliant, although the attendance would be registered in the database with a comment that no information had been collected.

Data were lost if the dictaphone was prepared incorrectly resulting in a blank tape.

2.7.1 Clinical data entry

The dental data were keyed by a clerk (31-month data) and later by the author (43- and 61-month data). The decision to key data in this way was made to minimise costs and reduce time spent checking data entry and interpreting the examiners' additional comments.

2.8 Modification of the data

Following initial examination of the data, further modification was carried out on some study variables and questionnaire data. This was necessary as some variables produced groups of cases that were too small to allow meaningful analysis to be carried out.

2.8.1 Modification of tooth condition data

The tooth variables were modified so that evidence of caries experience (past or present) was recorded without consideration of the number of surfaces affected, as illustrated in Table 2.12.

Table 2.12: Modified tooth condition data

Code	Modified tooth condition
0	Tooth sound
C1 C2 C3	Untreated caries present
F1 F2 F3	Restorations present
X	Extracted tooth
9 or system missing	Missing case

2.8.2 Modification of upper and lower labial segment alignment data

The alignment of the upper and lower labial segment and the presence or absence of a median diastema (Section 2.5.2) were divided into 'spaced' or 'not spaced' groups using the criteria in Table 2.13.

Table 2.13: Modified labial segment (U/L) alignment data

Labial alignment (U/L) and diastema (M)	Interpretation
Well-aligned, no median diastema (K+No M)	Not spaced
Crowded, no median diastema (C+No M)	Not spaced
Crowded, median diastema (C+M)	Not spaced
Spaced, no median diastema (S+No M)	Spaced
Spaced, median diastema (S+M)	Spaced
Well-aligned, median diastema (K+M)	Spaced
Well-aligned, median diastema not specified (K+Q)	Missing
U not specified, median diastema (Q+M)	Missing
U not specified, no median diastema (Q+No M)	Missing
Unable to determine either variable (Q+Q)	Missing

2.8.3 Modification of anterior occlusion data

The anterior occlusion (AOB) (Section 2.5.3.1) was modified to produce a new variable (A) in which the anterior occlusion was recorded as either normal (no open bite) or affected (symmetrical or unilateral open bite) as in Table 2.14.

Table 2.14: Modified anterior occlusion data

Anterior occlusion	Modified anterior occlusion
Positive overbite or edge-to-edge incisor relationship	No open bite
Symmetrical anterior open bite	Open bite
Anterior open bite exaggerated on the right	Open bite
Anterior open bite exaggerated on left	Open bite
Unable to categorise	Missing

2.8.4 Modification of posterior occlusion data

The variables for the right and left posterior occlusion (Section 2.5.3.2) were modified as illustrated in Table 2.15.

Table 2.15: Modified posterior occlusion data

Posterior occlusion variable (XR + XL)	Modified posterior occlusion (Xbite)
Normal occlusion	No posterior crossbite
Unilateral crossbite	Posterior crossbite
Bilateral crossbite	Posterior crossbite

2.8.5 Modification of erosion data

The erosion variables (Section 2.5.4) were modified so that evidence of erosion was recorded without consideration of the extent of the erosion, as illustrated in Table 2.16.

Table 2.16: Modified erosion data

Code	Modified erosion status
0	No erosion present
1 2 3	Erosion present
9 or system missing	Missing

2.8.6 Modification of questionnaire data

The carer was asked to report on the digit and dummy sucking habits of the child at 15-, 24- and 36-months of age (Appendix 1.3). The question asked 'Does your child suck…?', but did not ask the duration of the habit. The information was collected via self-completed questionnaires and was further modified as illustrated in Table 2.17.

Table 2.17: Modified sucking habit data

Information collected on digit or dummy sucking habit	Modified sucking habit
Child does not suck	Never sucks
Child sucks most of the time Child sucks some of the time	Child sucks
Question not answered	Missing

2.9 Reproducibility

2.9.1 Trainer

The trainer, a qualified dentist and the author, was accepted as the 'Gold Standard' throughout the study. At the time of each clinic (at 31-, 43- and 61-months), a reproducibility study was carried out. The trainer examined thirty children, who were not involved in the CIF study, on two occasions (not less than a week apart) and the data were analysed statistically.

2.9.2 Examiners

To check the reproducibility of the examiners, the trainer repeated examination on around 30 children per examiner at 31-, 43- and 61-months (Table 2.18). The number varied due to availability of the examiners and trainer. The repeat examination took place immediately after the initial data collection with the data being entered on the same side of the tape. When the trainer was available, all of the children who attended the clinic were re-examined.

Table 2.18: Repeat examinations for reproducibility

	Examiners								
	1	2	3	4	5	6	7	8	9
31-month clinic	28	31	31	29	30	15			
43-month clinic	29	31	33				35	32	36
61-month clinic	34	33							

2.10 Statistics

The data were keyed into a database (Microsoft Access 2.0) and later imported into SPSS 9.0 for Windows, statistical package.

Three non-parametric statistical tests were used in this study. The p value is accepted as significant if $p \leq 0.05$.

Parametric tests provide higher levels of confidence. However, they rely on data being normally distributed. Therefore, data must be tested for skew and kurtosis and to determine whether the variance of groups is similar. It is known that ALSPAC data is non-normally distributed and therefore parametric tests are not suitable and non-parametric tests are required.

2.10.1 Kappa (κ)

Kappa is a non-parametric test used to show differences between groups using categorical data.

The measurement of inter-rater agreement (reproducibility of the examiners) was reported using the non-weighted kappa statistic. This produced a measurement of agreement from 1.00 (perfect or complete agreement) to <0.20 (poor agreement) using the interpretation in Table 2.19 (Landis and Koch 1977).

Table 2.19: Interpretation of kappa values

Value of kappa	Strength of agreement
≤0.20	Poor
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Good
0.81-1.00	Very good

2.10.2 Chi-squared distribution test (χ^2)

This test is used to compare proportions within two categorical variables. The value of Chi-squared and its associated p value, test the null hypothesis that the two variables occur independently of each other. A p value <0.05 indicates rejection of the null hypothesis, i.e. the proportions in the categories of one variable are dependent on the proportions of the categories of the other variable.

In this study, χ^2 is used in two situations. These are:

i. To illustrate the change of the same study variable with time. It is expected that p<0.0001 in this case, as a variable at one time-point is highly dependent on the same variable measured at a later time-point. If it were not, then this would suggest inconsistency in the data either as a result of the data being collected from two differing study groups or errors in diagnosis and data collection. To compare the change over time, only cases with data available at 31-, 43- and 61-months were included in the analysis.

ii. To identify the possible influence of external factors on dental features. For example, maternal age at delivery was analysed with the caries experience of the study group at 31-, 43- and 61-months. In this case, all cases (867) were included in the analysis, as the statistical package will exclude missing cases automatically. As the statistic is used to determine influence at time-points rather than effects over time, it is unwise to lose too many cases in the analysis, since substantial sample reduction would reduce the power of the test and hence the p value.

When the number of children in a group was five or under then Fisher's exact test was used to assess significance.

2.10.3 Mann-Whitney non-parametric test for independent samples

Many statistical tests of continuous data rely on the assumption that the data is normally distributed. However, often this is not the case and non-parametric tests are required. The frequency of consumption of all foods and drinks were tested for normality and found to be highly skewed to the left as a large number of children were not consuming them at all. Therefore, the Mann-Whitney test (the non-parametric equivalent of the t-test) is used to test whether there is a difference in the median frequency of consumption of foods and drinks according to the two levels of a specified variable, such as the presence of dental caries or erosion (yes or no). The test combines and ranks the observations from both groups and sums them. The associated p value indicates any significant differences between the median frequency of consumption and the levels of the second variable.

CHAPTER 3

RESULTS OF REPRODUCIBILITY STUDIES

3.1 Introduction

Historically, in the United Kingdom, the collection of dental survey data has been carried out by qualified dentists (Section 1.2), whose salaries alone constitute a large part of the overall running costs.

In the United Kingdom, dental auxiliaries (hygienists and therapists) are closely regulated by the General Dental Council and may only work under the direct supervision of a dentist (General Dental Council 2000). Within this sphere of practice, auxiliaries may not diagnose dental disease and are currently not employed to collect survey data. However, studies have shown that auxiliaries can be trained to collect data to an acceptable standard (Kwan *et al.* 1996, 1998).

Epidemiological survey criteria are very different from those of caries diagnosis as the former employs strict diagnostic guidelines, whereas the latter uses a number of subjective decisions regarding the clinical extent of the disease.

Kwan *et al.* (1996) looked at the feasibility of auxiliaries collecting dental data from children and found that they were able to record data comparable to that of a dental officer who was regarded as the 'Gold Standard'.

A further study compared data collection between a group of hygienists and therapists (Kwan *et al.* 1998.). All observers were experienced in dealing with 5 and 12-year-old children. The results were encouraging and showed that auxiliaries could produce data to an acceptable standard (kappa ≥ 0.75) following appropriate training and calibration.

The ALSPAC study has a limited budget and it is essential to keep costs low. Therefore, it is important to investigate methods to collect dental data efficiently and effectively at a minimum cost.

Non-dental health care professionals were trained by a dentist to identify dental caries, occlusal features and dental erosion using strict survey criteria. Reproducibility studies were carried out at the same time as data collection for the three CIF clinics (Section 2.9).

3.2 Results of the Reproducibility Studies

3.2.1 Trainer-reproducibility study using non-CIF data

The trainer repeated examinations on samples of non-CIF children to coincide with each of the three CIF clinics (Section 2.9.1). The data were analysed using the kappa statistic to determine levels of agreement. The results were interpreted using the guidelines in Table 2.19. Complete tables of kappa values for all study variables for each non-CIF sample (trainer's reproducibility) are given in Appendix 4. There were 31 study variables in total (22 tooth, 8 arch form and 1 tongue) for the 31- and 43-month clinics and 35 (26 tooth, 8 arch form and 1 tongue) for the 61-month clinic. The study variables that gave measures of agreement of less than 1.00 for each of the three sample studies are listed in Tables 3.1, 3.2 and 3.3 respectively.

3.2.1.1 Trainer-reproducibility at the time of the 31-month CIF clinic

The kappa values produced for five of the 31 study variables showed excellent strength of agreement (kappa=1.00). Kappa was not calculated for 18 of the variables as two-way tables were not produced (Appendix 4). The remaining seven variables produced kappa values ≥0.475 and these are listed in Table 3.1. The lowest kappa score was produced for the lower median diastema (LM) and was 0.475 (moderate agreement). Close scrutiny of the recorded cases for LM revealed that two of the 31 cases differed at the repeat examination. These cases were both reported to have spacing in the lower labial segment, although the spacing in the midline was not recorded as being exaggerated when compared with other spacing in the segment. If the variable for the lower median diastema (LM) were ignored, then the cases would still be assessed as having spacing in the lower labial segment (L). The value of kappa for each variable fell within the range of the 95% confidence intervals.

3.2.1.2 Trainer-reproducibility at the time of the 43-month CIF clinic

Seventeen of the 31 study variables gave levels of agreement of 1.00 (Appendix 4). Kappa was not calculated for seven of the variables since the value of the variable was a constant and a two-way table could not be produced. The seven variables that produced kappa values of <1.00 are in Table 3.2. The strength of agreement for these variables was good or better ($\kappa \geq 0.645$), except for the lower median diastema (LM) which was fair ($\kappa = 0.275$) and the upper right lateral incisor (52), which was moderate ($\kappa = 0.476$). However, in each case, the value of kappa fell within the 95% confidence interval.

auxiliaries could produce data to an acceptable standard (kappa ≥ 0.75) following appropriate training and calibration.

The ALSPAC study has a limited budget and it is essential to keep costs low. Therefore, it is important to investigate methods to collect dental data efficiently and effectively at a minimum cost.

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3.2.1.1 Trainer-reproducibility at the time of the 31-month CIF clinic

The kappa values produced for five of the 31 study variables showed excellent strength of agreement (kappa=1.00). Kappa was not calculated for 18 of the variables as two-way tables were not produced (Appendix 4). The remaining seven variables produced kappa values ≥0.475 and these are listed in Table 3.1. The lowest kappa score was produced for the lower median diastema (LM) and was 0.475 (moderate agreement). Close scrutiny of the recorded cases for LM revealed that two of the 31 cases differed at the repeat examination. These cases were both reported to have spacing in the lower labial segment, although the spacing in the midline was not recorded as being exaggerated when compared with other spacing in the segment. If the variable for the lower median diastema (LM) were ignored, then the cases would still be assessed as having spacing in the lower labial segment (L). The value of kappa for each variable fell within the range of the 95% confidence intervals.

3.2.1.2 Trainer-reproducibility at the time of the 43-month CIF clinic

Seventeen of the 31 study variables gave levels of agreement of 1.00 (Appendix 4). Kappa was not calculated for seven of the variables since the value of the variable was a constant and a two-way table could not be produced. The seven variables that produced kappa values of <1.00 are in Table 3.2. The strength of agreement for these variables was good or better (κ≥0.645), except for the lower median diastema (LM) which was fair (κ=0.275) and the upper right lateral incisor (52), which was moderate (κ=0.476). However, in each case, the value of kappa fell within the 95% confidence interval.

Five of the arch form variables had also given levels of agreement of <1.00 in the 31-month trainer-reproducibility study. Four of these variables, those for upper labial segment (U), upper median diastema (UM), lower median diastema (LM) and right posterior occlusion (XR), produced lower kappa values in the 43-month trainer-reproducibility study. The lower median diastema (LM) gave the lowest kappa value in both studies, although values were within 95% confidence intervals.

3.2.1.3 Trainer-reproducibility at the time of the 61-month CIF clinic

i Tooth and arch form study variables

At the 61-month study, the first permanent molars (56, 66, 76 and 86) were included in the tooth variables giving a total of 35 study variables. Twelve variables had kappa values of <1.00 and are in Table 3.3. The other variables produced kappa values of 1.00 (9 variables) showing perfect agreement or had constant values (10 variables) so that kappa could not be calculated (Appendix 4). The 12 variables which produced kappa values <1.00 showed good or very good agreement (kappa ≥0.654).

ii Dental erosion study variables

Twenty dental erosion variables were recorded for each case. Kappa values for the assessment of erosion on the labial aspect of the upper left lateral incisor (62LD and 62LA) could not be calculated, as the values of the variable were a constant. Four variables for the depth and area of labial erosion of the upper right lateral incisor (52LD and 52LA) and occlusal erosion of the lower left molar (74OD and 74OA) produced perfect agreement (κ=1.00, Appendix 4). Fourteen of the erosion variables gave kappa values <1.00 (Table 3.4). The labial erosion variables produced better measures of agreement than those for palatal erosion. The lowest kappa value was that for the depth of palatal erosion of the upper right lateral incisor (52PD) which was 0.367 (fair). However, this was within the 95% confidence interval. Eight of the repeated cases for this variable differed between the first and second examinations. Two other palatal erosion variables, those for upper right central incisor – depth (51PD) and upper left lateral incisor – depth (62PD), showed moderate agreement, with seven and four cases differing in the repeat examination, respectively.

The assessment of the lower right first primary molar (84) produced good measure of agreement for both occlusal depth (84OD) and area (84OA, κ=0.641).

iii Modified dental erosion study variables

The erosion variables were modified such that analysis of the detection of erosion, rather than the depth and area affected, could be assessed (Section 2.8.5). All variables were recoded as 0 (no erosion detected) or 1 (erosion detected). Those that could not be categorised (originally coded 9) were omitted. The recoded variables were then analysed using kappa and the results of this modification and 95% confidence levels are shown in Table 3.5. Values for the trainer-reproducibility of 20 modified variables are in Appendix 4. Improved levels of agreement were produced for some variables. The eight variables for palatal erosion had kappa values of <1.00, and were within 95% confidence intervals (κ≥0.526).

3.2.2 Examiner-reproducibility study at the CIF clinics

The reproducibility of the examiners' data was measured by comparing the data collected at the first examination with that obtained by the trainer at the repeat examination for 164, 196 and 67 cases at the 31-, 43- and 61- month CIF clinics, respectively (Section 2.9.2). The data were analysed using kappa and the complete results of the analysis for all three clinics are in Appendix 4.

3.2.2.1 Examiner-reproducibility at the 31-month clinic

The data for 164 cases were available for analysis of the examiner-reproducibility at the 31-month clinic. Eleven study variables produced complete agreement (κ=1.00) and eight of the variables were a constant so that kappa could not be computed (Appendix 4). Twelve of the 31 variables produced kappa values <1.00 and these are presented in Table 3.6.

These 12 variables showed levels of agreement of moderate or better ($\kappa \geq 0.606$), with all falling within the 95% confidence interval. Only one variable (right posterior occlusion, XR) produced a moderate score with eight cases differing between the examiner's (initial) and trainer's (repeat) examination. Four variables produced good levels of agreement ($\kappa \geq 0.745$). Of these the variable for left posterior occlusion (XL) differed in five cases. The remaining seven variables showed very good agreement ($\kappa \geq 0.859$) despite a difference in 14 cases for the lower labial segment (L) and in eight cases for the upper left second primary molar (65) and lower right second primary molar (85).

3.2.2.2 Examiner-reproducibility at the 43-month clinic

One hundred and ninety six cases were subjected to a repeat examination for the purposes of the examiner-reproducibility study at the 43-month clinic. A complete table of the kappa values for the study variables (31 in total) is in Appendix 4. The seven tooth and eight arch form variables that produced kappa values <1.00 are in Table 3.7.

Both the tooth and arch form variables for the 43-month clinic showed greater variation in their kappa values than those for the 31-month clinic. The tooth variables that produced kappa values <1.00 ranged from 0.323 (fair) for the lower right second molar (85), which differed in four cases, to 0.798 (good) for the upper right lateral incisor (52), which differed in three cases.

The arch form variables varied from κ=0.482 (moderate agreement) for the upper labial segment (U) despite differing in 57 cases, to κ=0.745 (good) for reverse overjet (ROJ) which differed in two cases.

3.2.2.3 Examiner-reproducibility at the 61-month clinic

Sixty-seven cases had repeat examinations carried out to enable examiner-reproducibility to be determined. Tooth and arch form study variables are reported separately from the dental erosion variables.

i Tooth and arch form study variables

Four tooth variables (for all four first permanent molar teeth) were added to the 31 variables recorded at the 31- and 43-month clinics. The kappa values for all 35 variables are given in Appendix 4. Ten of these variables produced perfect agreement. Thirteen variables produced kappa values <1.00 and are listed in Table 3.8.

The kappa values for these variables ranged from -0.024 (poor) (p=0.825) for the lower left second molar (75), which was outside the 95% confidence interval, to 0.882 (very good) for the upper left second molar (65). The levels of agreement for the right posterior occlusion (XR) and left posterior occlusion (XL) were 0.634 (good) and 0.917 (very good), respectively. This was an improvement in the levels produced in the two previous examiner–reproducibility studies where the strength of agreement was moderate (XR) and good (XL) in each.

Table 3.9 gives values for modified tooth study variables. The modified variables were produced by recording the number of teeth with caries and restorations without quantification of the number of surfaces involved (Section 2.8.1). The values for all 35 variables are given in Appendix 4. The results show an improved score for the assessment of the lower left second molar (75) from –0.024 (poor) to 0.477 (moderate) which was within the 95% confidence interval. Four tooth variables produced lower scores, although they still produced good strength of agreement.

ii Dental erosion study variables

The kappa values for the 20 dental erosion study variables are tabulated in Appendix 4. Fourteen of the 20 dental erosion study variables produced kappa values of <1.00 and these are listed in Table 3.10.

Labial erosion produced better levels of agreement than palatal erosion. The reproducibility of the 8 study variables for palatal erosion (both depth and area of erosion) for each of the upper incisors, gave levels of agreement ranging from 0.237 (fair) to 0.415 (moderate). Both variables for each of the lower primary first molars (74 and 84) gave levels of agreement of 0.377 (fair) and 0.792 (good), respectively.

iii Modified dental erosion study variables

The dental erosion study variables were modified in the same way as those in the trainer-reproducibility study such that the tooth surfaces affected by erosion were recorded, although the extent of the erosion (depth and area affected) was not recorded. All variables were recoded as 0 (no erosion detected) or 1 (erosion detected). The recoded variables were then analysed using kappa. A table showing the values for all 20 modified variables is in Appendix 4. Ten variables could not be computed as two-way tables could not be produced or the variable was a constant. The results of the modification of the variables with $\kappa<1.00$ are in Table 3.11.

Whilst the modification improved the scores for the majority of dental erosion variables, it considerably lowered the kappa value for the variables for the labial surface of the upper left central incisor (61LD and 61LA) from fair to poor and the rates were outside the 95% confidence intervals.

3.2.2.4 Examiner reproducibility of caries experience (dmft) at the 31-, 43- and 61-month clinics

The caries experience (dmft=0 or dmft>0) and the individual components of *dmft* recorded by the examiners at 31-, 43- and 61- months were compared with those recorded by the trainer using the kappa statistic (Table 3.12).

The reproducibility of *dmft* at 31-months was very good (κ=0.827) and decreased at 43- and 61-months (κ=0.669 and 0.634, respectively). This may be due to the rise in caries experience with the group at 43- and 61-months, and might also be due to the larger number of examiners at the 43-month clinic. Even so, perfect agreement was reached when the missing teeth were cross-tabulated (κ=1.00). The lowest level of agreement was in the proportion of cases with restorations at 61-months (κ=0.849, moderate). This may be due to the difficulties in discerning between the tooth and white filling materials, which are more commonly used in the primary dentition than amalgam, which would be more readily seen.

3.3 Summary of reproducibility studies

The reproducibility of the trainer was generally good or better at each clinic with the exception of the assessment of the presence of the lower median diastema. Reproducibility of dental erosion improved when the presence of erosion was considered, rather than the depth and area of tooth affected.

The reproducibility of the examiners was generally good or better for the 31- and 43-month clinics, with the exception of the assessment of caries of upper second molars and posterior crossbite. However, greater variation in the level of agreement was seen at 61-months, particularly for the assessment of caries in second molars. Some improvement was seen when the presence of caries was recorded, rather than consideration of the number of tooth surfaces affected.

The levels of assessment of incisor erosion remained fair, despite modification of the data.

The reproducibility of the caries experience and *the individual components* was good, although recognition of restorations at 61-months produced only moderate agreement (κ=0.489).

Table 3.1: Trainer-reproducibility at the 31-month clinic

Study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
65	31	0.652	Good	0.02-1.28
U	30	0.934	Very good	0.81-1.06
UM	30	0.870	Very good	0.62-1.12
L	30	0.868	Very good	0.69-1.04
LM	31	0.475	Moderate	-0.12-1.07
XR	31	0.783	Good	0.37-1.19
T	31	0.652	Good	0.02-1.28

Key:

65	Upper left primary second molar
U	Upper labial segment
UM	Upper median diastema
L	Lower labial segment
LM	Lower median diastema
XR	Right posterior occlusion
T	Tongue

Table 3.2: Trainer-reproducibility at the 43-month clinic

Study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
52	33	0.476	Moderate	-0.14-1.09
U	33	0.782	Good	0.59-0.97
UM	33	0.645	Good	0.34-0.95
L	30	0.936	Very good	0.81-1.06
LM	33	0.275	Fair	-0.23-0.78
XR	33	0.653	Good	0.02-1.28
XL	33	0.653	Good	0.02-1.28

Key:

52	Upper right primary lateral incisor
U	Upper labial segment
UM	Upper median diastema
L	Lower labial segment
LM	Lower median diastema
XR	Right posterior occlusion
XL	Left posterior occlusion

Table 3.3: Trainer-reproducibility at the 61-month clinic

Study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
65	36	0.789	Good	0.39-1.19
66	37	0.654	Good	0.03-1.28
76	36	0.654	Good	0.03-1.28
75	36	0.899	Very good	0.7-1.1
71	37	0.846	Very good	0.55-1.14
81	37	0.877	Very good	0.64-1.11
84	36	0.789	Good	0.39-1.19
85	36	0.789	Good	0.39-1.19
U	37	0.775	Good	0.59-0.96
UM	37	0.720	Good	0.46-0.97
L	35	0.712	Good	0.5-0.92
XR	37	0.786	Good	0.38-1.19

Key:

65	Upper left primary second molar
66	Upper left permanent first molar
76	Lower left permanent first molar
75	Lower left primary second molar
71	Lower left permanent central incisor
81	Lower right permanent central incisor
84	Lower right primary first molar
85	Lower right primary second molar
U	Upper labial segment
UM	Upper median diastema
L	Lower labial segment
XR	Right posterior occlusion

Table 3.4: Trainer-reproducibility at the 61-month clinic (erosion)

Dental erosion study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
51LD	37	0.654	Good	0.03-1.28
51LA	37	0.654	Good	0.03-1.28
61LD	37	0.786	Good	0.38-1.19
61LA	37	0.786	Good	0.38-1.19
52PD	35	0.367	Fair	-0.2-0.93
52PA	37	0.636	Good	0.25-1.02
51PD	37	0.589	Moderate	0.34-0.84
51PA	37	0.649	Good	0.4-0.9
61PD	37	0.672	Good	0.44-0.9
61PA	37	0.727	Good	0.5-0.95
62PD	37	0.515	Moderate	0.15-0.88
62PA	37	0.635	Good	0.26-1.01
84OD	37	0.641	Good	0.19-1.09
84OA	37	0.641	Good	0.19-1.09

Key:

51	Upper right primary central incisor
52	Upper right primary lateral incisor
61	Upper left primary central incisor
62	Upper left primary lateral incisor
84	Lower right primary first molar
LD	Depth of labial erosion
LA	Area of labial erosion
PD	Depth of palatal erosion
PA	Area of palatal erosion
OD	Depth of occlusal erosion
OA	Area of occlusal erosion

Table 3.5: Trainer-reproducibility at the 61-month clinic (modified erosion)

Modified dental erosion study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
52PD	36	0.526	Moderate	0.06-1.0
52PA	36	0.526	Moderate	0.06-1.0
51PD	35	0.615	Good	0.31-0.91
51PA	35	0.615	Good	0.31-0.91
61PD	34	0.612	Good	0.31-0.91
61PA	34	0.612	Good	0.31-0.91
62PD	37	0.626	Good	0.25-1.0
62PA	37	0.626	Good	0.25-1.0

Key:

51	Upper right primary central incisor
52	Upper right primary lateral incisor
61	Upper left primary central incisor
62	Upper left primary lateral incisor
PD	Depth of palatal erosion
PA	Area of palatal erosion

Table 3.6: Examiner-reproducibility at the 31-month clinic

Study variables where kappa <1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
51	164	0.798	Good	0.41-1.19
61	164	0.798	Good	0.41-1.19
65	164	0.897	Very good	0.83-0.97
75	164	0.957	Very good	0.91-1.01
85	163	0.902	Very good	0.83-0.97
U	164	0.923	Very good	0.86-0.98
UM	164	0.887	Very good	0.8-0.97
L	163	0.859	Very good	0.79-0.93
AOB	164	0.951	Very good	0.9-1.0
ROJ	164	0.745	Good	0.4-1.09
XR	162	0.606	Moderate	0.32-0.89
XL	164	0.784	Good	0.6-0.97

Key:

51	Upper right primary central incisor
61	Upper left primary central incisor
65	Upper left primary second molar
75	Lower left primary second molar
85	Lower right primary second molar
U	Upper labial segment
UM	Upper median diastema
L	Lower labial segment
AOB	Anterior occlusion
ROJ	Reverse overjet
XR	Right posterior occlusion
XL	Left posterior occlusion

Table 3.7: Examiner-reproducibility at the 43-month clinic

Study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
55	196	0.326	Fair	-0.16-0.82
52	194	0.798	Good	0.41-1.18
51	195	0.764	Good	0.5-1.02
61	195	0.606	Moderate	0.29-0.92
75	194	0.661	Good	0.3-1.02
74	190	0.664	Good	0.05-1.28
85	194	0.323	Fair	-0.02-0.66
U	196	0.482	Moderate	0.37-0.59
UM	196	0.668	Good	0.54-0.8
L	196	0.647	Good	0.55-0.74
LM	196	0.739	Good	0.57-0.91
AOB	196	0.724	Good	0.61-0.84
ROJ	196	0.745	Good	0.4-1.09
XR	195	0.558	Moderate	0.3-0.8
XL	192	0.676	Good	0.45-0.9

Key:

55	Upper right primary second molar	U	Upper labial segment
52	Upper right primary lateral incisor	UM	Upper median diastema
51	Upper right primary central incisor	L	Lower labial segment
61	Upper left primary central incisor	LM	Lower median diastema
75	Lower left primary second molar	AOB	Anterior occlusion
74	Lower left primary first molar	ROJ	Reverse overjet
85	Lower right primary second molar	XR	Right posterior occlusion
		XL	Left posterior occlusion

Table 3.8: Examiner-reproducibility at the 61-month clinic (tooth variables)

Study variables, excluding dental erosion where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
56	66	0.660	Good	0.04-1.28
55	66	0.407	Moderate	0.01-0.8
65	65	0.882	Very Good	0.65-1.1
76	67	0.793	Good	0.4-1.19
75	65	-0.024	Poor	-0.06-0.01
85	67	0.793	Good	0.4-1.19
U	67	0.529	Moderate	0.36-0.7
UM	67	0.756	Good	0.56-0.95
L	64	0.582	Moderate	0.41-0.75
LM	64	0.573	Moderate	0.21-0.94
AOB	66	0.817	Very Good	0.57-1.06
XR	67	0.634	Good	0.3-0.96
XL	67	0.917	Very Good	0.67-1.16

Key:

56	Upper right permanent first molar
55	Upper right primary second molar
65	Upper left primary second molar
76	Lower left permanent first molar
75	Lower left primary second molar
85	Lower right primary second molar
U	Upper labial segment
UM	Upper median diastema
L	Lower labial segment
LM	Lower median diastema
AOB	Anterior occlusion
XR	Right posterior occlusion
XL	Left posterior occlusion

Table 3.9: Examiner-reproducibility at the 61-month clinic (modified tooth variables)

Modified study variables, excluding dental erosion, where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
56	66	0.660	Good	0.04-1.28
55	66	0.548	Moderate	0.09-1.0
61	67	0.794	Good	0.4-1.19
64	67	0.794	Good	0.4-1.19
65	66	0.881	Very good	0.65-1.11
76	67	0.793	Good	0.4-1.19
75	67	0.477	Moderate	0.04-0.91
74	67	0.655	Good	0.21-1.1
85	67	0.793	Good	0.4-1.19

Key:

56	Upper right permanent first molar
55	Upper right primary second molar
61	Upper left primary central incisor
64	Upper left primary first molar
65	Upper left primary second molar
76	Lower left permanent first molar
75	Lower left primary second molar
74	Lower left primary first molar
85	Lower right primary second molar

Table 3.10: Examiner-reproducibility at the 61-month clinic (erosion)

Dental erosion study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
51LD	67	0.660	Good	0.04-1.28
51LA	67	0.660	Good	0.04-1.28
52PD	66	0.415	Moderate	0.13-0.70
52PA	66	0.440	Moderate	0.16-0.72
51PD	64	0.237	Fair	0.01-0.47
51PA	67	0.281	Fair	0.07-0.49
61PD	67	0.285	Fair	0.09-0.48
61PA	67	0.308	Fair	0.1-0.52
62PD	67	0.357	Fair	0.08-0.63
62PA	67	0.296	Fair	0.04-0.55
74OD	66	0.377	Fair	-0.18-0.93
74OA	66	0.377	Fair	-0.18-0.93
84OD	65	0.792	Good	0.4-1.19
84OA	65	0.792	Good	0.4-1.19

Key:

51	Upper right primary central incisor
52	Upper right primary lateral incisor
61	Upper left primary central incisor
62	Upper left primary lateral incisor
74	Lower left primary first molar
84	Lower right primary first molar
LD	Depth of labial erosion
LA	Area of labial erosion
PD	Depth of palatal erosion
PA	Area of palatal erosion
OD	Depth of occlusal erosion
OA	Area of occlusal erosion

Table 3.11: Examiner-reproducibility at the 61-month clinic (modified erosion)

Modified dental erosion study variables where kappa < 1.00

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
61LD	66	-0.015	Poor	-0.04-0.01
61LA	66	-0.015	Poor	-0.04-0.01
52PD	66	0.449	Moderate	0.15-0.75
52PA	66	0.449	Moderate	0.15-0.75
51PD	65	0.340	Fair	0.08-0.6
51PA	65	0.340	Fair	0.08-0.6
61PD	66	0.390	Fair	0.14-0.64
61PA	66	0.390	Fair	0.14-0.64
62PD	67	0.385	Fair	0.1-0.67
62PA	67	0.385	Fair	0.1-0.67

Key:

51	Upper right primary central incisor
52	Upper right primary lateral incisor
61	Upper left primary central incisor
62	Upper left primary lateral incisor
LD	Depth of labial erosion
LA	Area of labial erosion
PD	Depth of palatal erosion
PA	Area of palatal erosion

Table 3.12: Examiner-reproducibility - caries experience at the 31-, 43- and 61-month clinics using modified tooth study variables

Variable	No. of valid cases	Measurement of agreement: kappa	Interpretation of kappa values	95% confidence intervals
dmft31	164	0.827	Very Good	0.59-1.06
dt31	164	0.744	Good	0.4-1.08
mt31	164	1.00	**	
ft31	164	*	*	
mft31	164	1.00	**	
dmft43	196	0.669	Good	0.51-0.83
dt43	196	0.506	Moderate	0.29-0.72
mt43	196	1.00	**	
ft43	196	0.659	Good	0.3-1.02
mft43	196	0.849	Very Good	0.68-1.01
dmft61	67	0.634	Good	0.39-0.88
dt61	67	0.674	Good	0.43-0.91
mt61	67	1.00	**	
ft61	67	0.489	Moderate	-0.11-1.09
mft61	67	0.653	Good	0.21-1.1

* Not computed as no restorations recorded ** Complete agreement

Key:
dmft: caries experience
dt: untreated caries
mt: missing teeth
ft: filled teeth
mft: missing plus restored teeth - restorative index

CHAPTER 4

COMPARISON OF THE CARIES EXPERIENCE OF THE CHILDREN AT 31-, 43- AND 61-MONTHS

4.1 Introduction

The WHO target for the year 2003 is for 50% of 5 to 6-year-olds to be caries-free (Fédération Dentaire Internationale 1982).

In 1997 the average caries experience (dmft) of 5-year-old children in the United Kingdom was 2.9. Variations from the mean ranged from 0.54 (West Midlands) to 3.96 (Manchester). It is well documented that pockets of increased dental disease exist within communities and that average figures provide a false picture of the dental state of the population at large.

There is no longitudinal data on the dental health of preschool children in the United Kingdom. BASCD surveys record the dental disease in samples of 5- and 12-year-old children at 10-yearly intervals. Between 1973 and 1983, the caries experience of 5-year-olds decreased (Todd 1975, Todd and Dodd 1985). However, recent figures have shown that caries levels did not improve between 1983 and 1993 (O'Brien 1994). The four Camden studies (Winter *et al.* 1971, Holt *et al.* 1982, 1988, 1996) have highlighted changing trends in dental caries in preschool children.

The National Diet and Nutrition Survey (Hinds and Gregory 1995) reported the dental status of a sample of 1.5 to 4.5-year-olds from 1992-1993 along with social and dietary data. The study found that although 83% of the children were caries-free, the 17% with caries experience had a large proportion of untreated caries (83%). In addition, a strong statistical association was demonstrated between dental caries and social background with increased prevalence in those of lower social class. This study was not longitudinal and predictors of dental disease could not be reliably identified.

In the present study, children were examined at three ages, 31-, 43- and 61-months of age. Additional information was obtained from questionnaires completed by the parents at regular intervals after the birth of the child. The dental records of the 867 children who attended all three CIF clinics therefore present an opportunity to obtain a longitudinal view of the dental health of the cohort. Complete records of tooth condition are available for 793 children and a detailed report of the caries experience (dmft) of these children follows. The BASCD survey criteria recommend that the *dmft* of 5-year-olds be assessed using primary canines and molars only, since the incisors may be beginning to exfoliate. Therefore, in order for direct comparison to be made between the 31-, 43- and 61-month clinics, *dmft* at 61-months was calculated twice, once to include all primary teeth and once to include canines and molars only.

4.2 Results

4.2.1 Tooth eruption and tooth condition

Figures 4.1 - 4.6 show the eruption and caries status of the teeth of the 867 children at the 31-, 43- and 61-month clinics. The data table below each graph shows the number of children within each category of the study variable. These tables are included to demonstrate the very small number of children with caries experience in the 31- and 43-month clinics compared with the 61-month clinic.

The second primary molars were unerupted in a proportion of children at the 31-month clinic. These ranged from 12.7% in the lower left quadrant to 18.0% in the upper left quadrant. A small number of canines were also unerupted (0.1 - 0.3%). At 43-months of age, all of the primary teeth had erupted within the 867 children studied. At the 61-month clinic the first permanent molars had erupted in around 3% of children. None of these teeth were carious.

4.2.2 Anomalies of teeth and soft tissues

Only one child was reported to have a supernumerary tooth. The tooth was present in the upper labial segment between the upper right central and lateral incisors.

Four children (0.5%) had congenitally absent teeth. The missing teeth were lateral incisors. Two children had two teeth absent in the lower labial segment, one had two teeth absent in the upper labial segment and the fourth case had an absent upper right lateral incisor. In all four children, the mother gave a history of non-eruption of these teeth.

Nine children (1.0%) had fused teeth present. Of these, three were in the upper labial segment and six were in the lower labial segment.

Two cases (0.2%) of abscessed teeth were recorded. These were both at the 61- month clinic and were both upper right central incisors. One of these teeth was also discoloured at the 61-month clinic, although there was no history of trauma and no record of discoloration at the previous clinics. The second case had been recorded as discoloured at the 43-month clinic, although no history of injury was given.

A total of thirty-four children (3.9%) had discoloured teeth (either upper or lower incisors) at either the 31-, 43- or 61-month clinics. Although these figures are small, the variables were compared and associations were seen ($p \leq 0.004$, Appendix 5.1). No association was found between the children recorded at 31- and 61-months ($p=0.172$). Only one of the cases recorded at the 31-month clinic was also recorded at the 61-month clinic. No information regarding the possible cause of the discoloration was available.

The data reporting the presence of tongue-tie was inconsistent. The numbers were small and cross-tabulation using χ^2 (Appendix 5.1), suggested that some children developed tongue-tie, which is clearly not the case. The children were reported by the examiners to be reluctant to protrude the tongue at any age even though many parents asked them to comply. Given the small number of reported cases with tongue-tie and the suspect nature of the results, it seemed prudent to accord them little credibility.

4.2.3 Comparison between the caries experience at the 31-, 43- and 61-month clinics

The dental disease present in these children is represented by the caries experience (dmft), which is the number of decayed, missing and filled primary teeth for each child (Table 4.1). Erupted permanent molar teeth were excluded, as were cases in which tooth variables were not determined (missing variables). Tables showing the distribution of the decayed (dt), missing (mt) and filled (ft) components of *dmft* and the restorative index (mft) are presented (Tables 4.2 to 4.5, respectively). The restorative index is the sum of the missing and filled components and is a record of treatment received by the children.

At the 31-month clinic, 97.2% (771) of the children were caries-free and the remaining 2.8% (22) had a *dmft* which ranged between 1 and 5. The mean *dmft* for the 793 children was 0.05, whilst the mean *dmft* of those with caries was 1.7. At the 43-month clinic, the proportion of children with caries (dmft>0) had increased to 13.5% (107) with 86.5% (686) caries-free. The mean *dmft* of the whole group was 0.3, ranging from 1 to 12. However, the mean *dmft* of the 107 children with caries was 2.2. The proportion of children with caries had increased further at the 61-month clinic and 25.9% (205) of the children had caries, whilst 74.1% (588) did not. The mean *dmft* of this group was 0.7, although the mean *dmft* of the 205 children was 2.8 and the highest *dmft* value was 13.

The *dmft* at 61-months, which excluded incisors, altered the proportion of children with caries to 21.4% (170). However, a significant rise in *dmft* was still apparent. The mean *dmft* of the children with caries increased to 3.1, although the mean *dmft* of the 793 children remained at 0.7. Therefore, as expected there is a significant increase in disease with age, with the concentration of the disease present in a minority of the study children.

At 61-months, 19.4% of the children had untreated caries (dt>0) and around 1% of this was present in the incisor region. The proportion of children with untreated caries increased steadily from 31- to 61-months (2% to 19.4%). However, extractions increased more gradually (0.8% to 7.2%) and if incisors were excluded at 61-months then only 3% of children (24) had received extractions (Table 4.3).

It is highly likely those children with a history of extraction at 61-months, had received treatment under general anaesthesia, since the majority (21, 2.6%) had lost two or more molars and had evidence of balanced extractions (Appendix 5.2).

Details of whether the child received dental treatment conscious, sedated or anaesthetised were collected later in the study. Analysis of these data is yet to be carried out.

4.2.3.1 Comparison of modified caries experience

Due to the small number of children with caries, particularly at the 31-month clinic, they were divided into those who were caries-free (dmft=0) and those with caries (dmft>0). The individual components of *dmft* were treated in the same way (Table 4.6 and Figure 4.7). This modification produced two larger groups for statistical analysis.

4.2.3.2 Modified caries experience and treatment received

Of the 2.8% (22) with caries experience (dmft>0) at the 31-month clinic, no restorations had been placed, although six children had experienced dental extraction. Two children had gone through the experience of having one tooth removed and four children had two teeth extracted. However, 2% (16) of the group also had untreated caries.

At the 43-month clinic, the proportion of children with untreated caries had increased to 11.3% (90), although the proportion of children who had received treatment had only increased to 3.4% (27). This figure comprised 1.8% who had experienced extraction and 1.6% who had received restorative care. Similar increases were noted between the 43- and 61-month clinics. At the 61-month clinic, 19.4% had a dmft>0. Although 12.4% had received treatment, 6% had restorations and 7.2% had missing teeth. The discrepancy in these figures is explained by some of the children having received both restorations and extractions.

4.2.3.3 Discrepancies in the caries data

The caries experience (dmft), decayed component (dt), missing component (mt) filled component (ft) and restorative index (mft) for the 31-month clinic were compared with those for the 43- and 61-month clinics, using the Chi-squared distribution test for trend (χ^2). One of the features of this test is that it will reveal cases that have been incorrectly coded, although it is not possible to determine at which clinic the cases were incorrectly assessed (Table 4.7).

Table 4.7 shows that 2.8% of the children had a dmft>0 at the 31-month clinic and that 68.2% of those still had a dmft>0 at the 43-month clinic. Clearly the remaining 31.8% of cases either did not have caries at the 31-month clinic or did have caries at the 43-month clinic that was not recorded. The same proportion did not have caries reported at the 61-month clinic (Table 4.8). Similarly 29% of cases recorded with a dmft>0 at the 43-month clinic were recorded as caries-free at the 61-month clinic (Table 4.9). The remaining analyses are in Appendix 5.3 and in each case the *dmft* at 61-months included all teeth to enable direct comparison to be made.

Since the data are from the same children at each of the three clinics, as expected all components of caries experience at one clinic were strongly associated with those at the other two clinics ($p<0.0001$).

4.3 Summary of the comparison of caries experience at the 31-, 43- and 61-month clinics

The proportion of children with a history of caries experience (dmft>0) increased with time in this study group. The proportion of children receiving care also increased with time with the largest increase occurring between the 43-month (3.4%) and 61-month clinics (12.4%).

Despite a recorded dental need, both the diagnostic criteria of the child's dentist and the compliance of the child will influence the delivery of active treatment and the choice of appropriate care. This in turn will influence the missing (mt) and filled component (ft) and ultimately the restorative index (mft). Given that a thorough professional examination may involve further clinical tests such as radiographs, then it might be expected that survey criteria underestimate the true level of dental disease in a population.

At the 31-month clinic, the only active treatment received by the children was dental extraction. This may have been related to non-compliance of the child because of their age and lack of understanding. In addition, if the initial attendance was due to pain then extractions may have been the preferred treatment option.

In general, children become more amenable to dental treatment as they grow older and as they become more familiar with the dental surroundings. By 43-months of age, it would be hoped that the child would be less apprehensive, particularly if they were regular attenders. This might be reflected in an increase in the filled component and this did occur in the 43- and 61-month clinics. However, the restorative index (mft) is a combination of the missing (mt) and filled (ft) components and the proportion of children with missing teeth had increased to 7.2% at the 61-month clinic. Around 4% of the children had lost incisors and it was not possible to confirm whether these teeth were extracted due to caries or trauma or whether they had exfoliated naturally.

In those cases where canines and molars had been lost, it was not possible to confirm whether orthodontic decisions had been made. However, a review of the extraction patterns in those children who had received multiple extractions, suggested that balancing and compensating extractions had been carried out in the majority of cases.

Table 4.1: Caries experience (dmft) of the 793 children in the study group

	31-month clinic		43-month clinic		61-month clinic (all teeth)		61-month clinic (canines & molars only)	
dmft	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
0	771	97.2	686	86.5	588	74.1	623	78.6
1	12	1.5	58	7.3	74	9.3	51	6.4
2	8	1.0	26	3.3	47	5.9	43	5.4
3			8	1.0	28	3.5	27	3.4
4	1	0.1	4	0.5	22	2.8	19	2.4
5	1	0.1	2	0.3	16	2.0	14	1.8
6			4	0.5	3	0.4	4	0.5
7			2	0.3	2	0.3	6	0.8
8			1	0.1	8	1.0	4	0.5
9					1	0.1	2	0.3
10					2	0.3		
11			1	0.1				
12			1	0.1	1	0.1		
13					1	0.1		
Children with caries experience (dmft >0)	22	2.8	107	13.5	205	25.9	170	21.4
Mean dmft of 793	0.05		0.3		0.7		0.7	
Mean dmft of those with caries	1.7		2.2		2.8		3.1	

Table 4.2: **Number (%) of children with decayed teeth (dt) of the 793 children who attended each clinic**

	31-month clinic		43-month clinic		61-month clinic (all teeth)		61-month clinic (canines & molars only)	
Number of decayed teeth	n	%	n	%	n	%	n	%
1	10	1.3	49	6.2	63	7.9	57	7.2
2	4	0.5	21	2.6	42	5.3	42	5.3
3			10	1.3	23	2.9	23	2.9
4	1	0.1	3	0.4	16	2.0	16	2.0
5	1	0.1	3	0.4	4	0.5	3	0.4
6			4	0.5	3	0.4	1	0.1
7							2	0.3
8					2	0.2		
9								
10					1	0.1		
Number (%) of children with dt>0	16	2.0	90	11.3	154	19.4	144	18.2
Number (%) of children with dmft>0	22	2.8	107	13.5	205	25.9	170	21.4

Table 4.3: Number (%) of children with missing teeth (mt) of the 793 children who attended each clinic

	31-month clinic		43-month clinic		61-month clinic (mt -all teeth)		61-month clinic (mt-canines & molars only)	
Number of missing teeth	n	%	n	%	n	%	n	%
1	2	0.2	5	0.6	26	3.3	3	0.4
2	4	0.5	5	0.6	11	1.4	4	0.5
3					4	0.5	2	0.3
4			1	0.1	8	1.0	9	1.1
5			1	0.1	4	0.5	3	0.4
6			1	0.1	2	0.2	2	0.3
7								
8			1	0.1	1	0.1	1	0.1
9								
10					1	0.1		
Number (%) of children with mt>0	6	0.8	14	1.8	57	7.2	24	3.0
Number (%) of children with dmft>0	22	2.8	107	13.5	205	25.9	170	21.4

Table 4.4: Number (%) of children with filled teeth (ft) of the 793 children who attended each clinic

	31-month clinic		43-month clinic		61-month clinic (ft -all teeth)		61-month clinic (ft-canines & molars only)	
Number of filled teeth	n	%	n	%	n	%	n	%
1			10	1.3	27	3.4	26	3.3
2					14	1.8	14	1.8
3			3	0.4	3	0.4	3	0.4
4					2	0.2	2	0.2
5					1	0.1	1	0.1
6								
7					1	0.1	1	0.1
Number (%) of children with ft>0	0	0.0	13	1.6	48	6.0	47	5.9
Number (%) of children with dmft>0	22	2.8	107	13.5	205	25.9	170	21.4

Table 4.5: Number (%) of children who had received treatment (mft) of the 793 children who attended each clinic

	31-month clinic		43-month clinic		61-month clinic (mft -all teeth)		61-month clinic (mft-canines & molars only)	
Number of missing or filled teeth	n	%	n	%	n	%	n	%
1	2	0.2	15	1.9	49	6.2	26	3.3
2	4	0.5	5	0.6	20	2.5	15	1.9
3			3	0.4	7	0.9	6	0.8
4			1	0.1	11	1.4	10	1.3
5			1	0.1	4	0.5	3	0.4
6			1	0.1	2	0.2	2	0.3
7					2	0.2	2	0.3
8			1	0.1	2	0.2	2	0.3
9								
10					1	0.1		
Number (%) of children with mft>0	6	0.8	27	3.4	98	12.4	66	8.3
Number (%) of children with dmft>0	22	2.8	107	13.5	205	25.9	170	21.4

Table 4.6: Caries experience of the children at the 31-, 43- and 61-month clinics

n=793	31-month clinic		43-month clinic		61-month clinic (all teeth)		61-month clinic (canines & incisors only)	
	n	%	n	%	n	%	n	%
dmft=0 Caries-free	771	97.2%	686	86.5%	588	74.1%	623	78.6%
dmft>0 Caries experience	22	2.8%	107	13.5%	205	25.9%	170	21.4%
dt>0 Untreated caries	16	2.0%	90	11.3%	154	19.4%	144	18.2%
mt>0 Missing teeth	6	0.8%	14	1.8%	57	7.2%	24	3.0%
ft>0 Restored teeth	0	0%	13	1.6%	48	6.0%	47	5.9%
mft>0 (Restorative index)	6	0.8%	27	3.4%	98	12.4%	66	8.3%

Table 4.7: Proportion of children with caries experience at the 31-month clinic (dmft31>0) by proportion of children with caries experience at the 43-month clinic (dmft43>0)

n=793 (100.0%)	dmft43=0 686 (86.5%)	dmft43>0 107 (13.5%)	χ^2	p value
dmft31=0 771 (97.2%)	679 88.1%	92 11.9%	58	<0.0001⁺
dmft31>0 22 (2.8%)	7 31.8%	15 68.2%		

⁺ Fisher's exact test

Table 4.8: Proportion of children with caries experience at the 31-month clinic (dmft31>0) by proportion of children with caries experience at the 61-month clinic (dmft61>0)

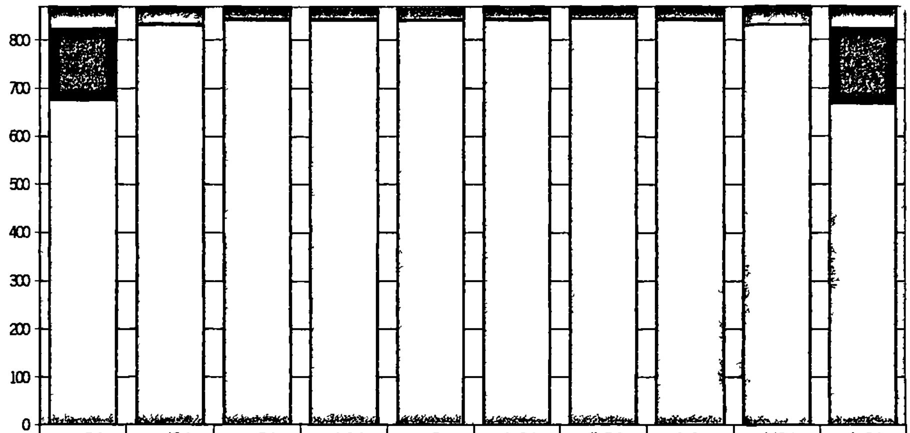
n=793 (100.0%)	dmft61=0 588 (74.1%)	dmft61>0 205 (25.9%)	χ^2	p value
dmft31=0 771 (97.2%)	581 75.4%	190 24.6%	21	<0.0001
dmft31>0 22 (2.8%)	7 31.8%	15 68.2%		

Table 4.9: Proportion of children with caries experience at the 43-month clinic (dmft43>0) by proportion of children with caries experience at the 61-month clinic (dmft61>0)

n=793 (100.0%)	dmft61=0 588 (74.1%)	dmft61>0 205 (25.9%)	χ^2	p value
dmft43=0 686 (86.5%)	557 81.2%	129 18.8%	132	<0.0001
dmft43>0 107 (13.5%)	31 29.0%	76 71.0%		

Figure 4.1: 31-month clinic - Upper arch tooth condition

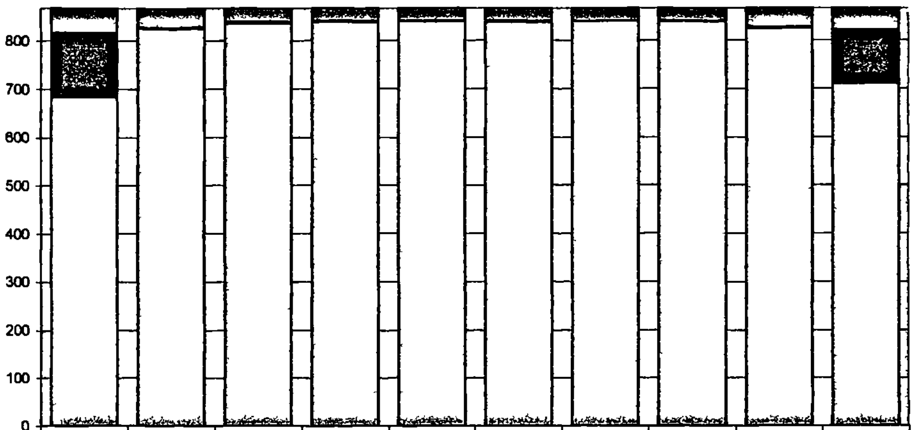
Right **Left**



	ure31	urd31	urc31	urb31	ura31	ula31	ulb31	ulc31	uld31	ule31
■ Not determined	45	37	25	24	24	24	24	25	38	45
■ Unerupted	147		2	2				3		156
□ Filled										
□ Missing		1		1	1		1			
■ Decayed	1	1	1	1	1	4			1	
■ Erupted and sound	674	829	839	839	837	839	842	839	828	666

Figure 4.2: 31-month clinic - Lower arch tooth condition

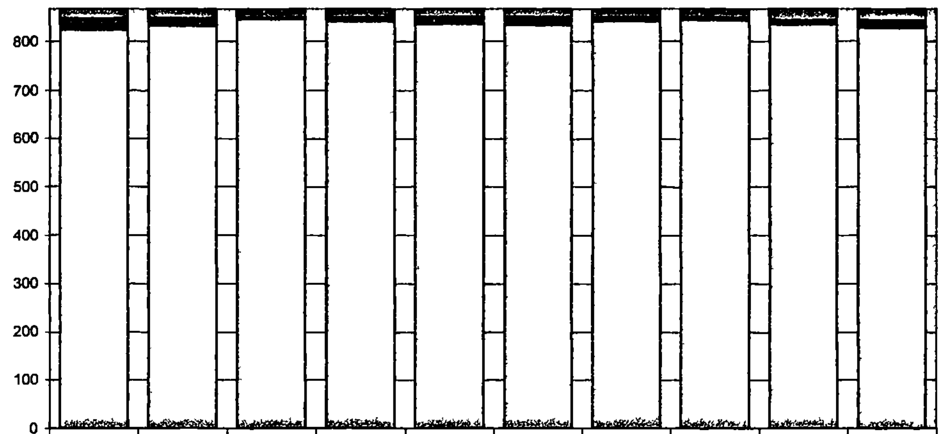
Right **Left**



	lre31	lrd31	lrc31	lrb31	lra31	lla31	llb31	llc31	lld31	lle31
■ Not determined	51	40	28	27	27	26	26	27	39	46
■ Unerupted	130		3					1		110
□ Filled										
□ Missing				2	1	2	1			
■ Decayed	3	3	1			1			3	2
■ Erupted and sound	683	824	835	838	839	838	840	839	825	709

Figure 4.3: 43-month clinic - Upper arch tooth condition

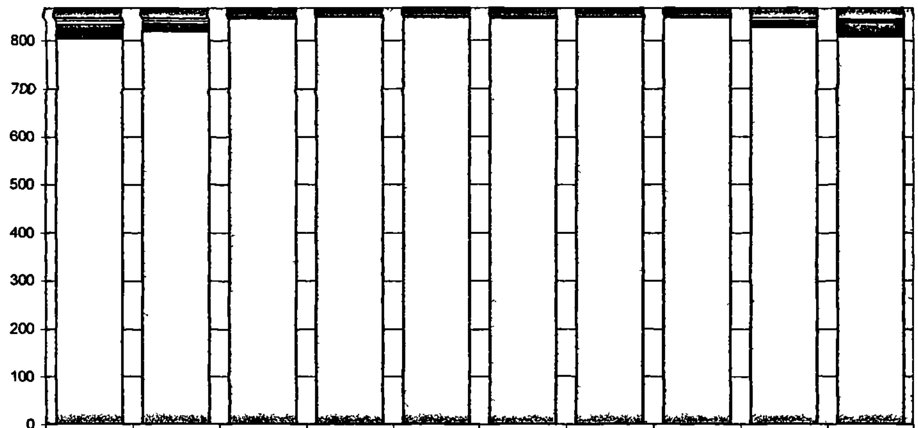
Right **Left**



	ure43	urd43	urc43	urb43	ura43	ula43	ulb43	ulc43	uld43	ule43
Not determined	20	20	18	18	17	17	18	18	23	23
Unerupted										
Filled	1	2							1	
Missing	3	3		3	3	3	1		2	3
Decayed	*20*	*11*	*4*	*5*	*12*	*14*	*8*	6	*7*	13
Erupted and sound	823	831	845	841	835	833	840	843	834	828

Figure 4.4: 43-month clinic - Lower arch tooth condition

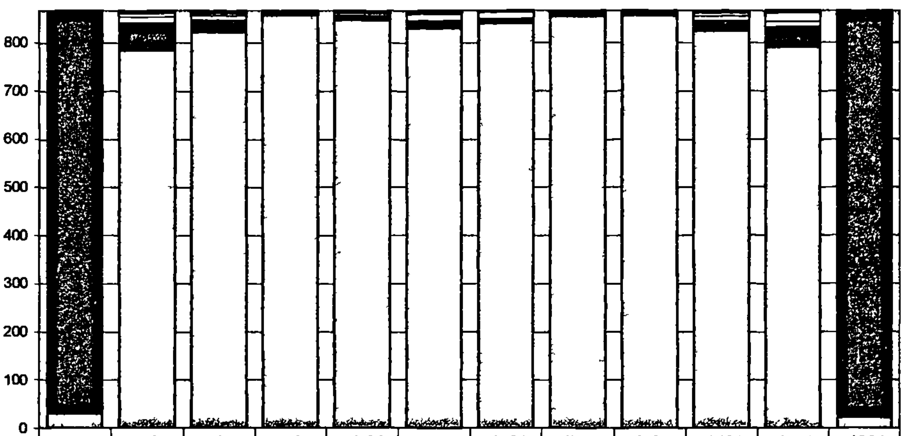
Right **Left**



	lre43	lrd43	lrc43	lrb43	lra43	lla43	llb43	llc43	lld43	lle43
Not determined	22	22	19	18	18	18	18	19	22	23
Unerupted										
Filled	4	5							5	3
Missing	7	4		1	2	2	1		2	4
Decayed	30	17	2			1		1	11	28
Erupted and sound	804	819	846	848	847	846	848	847	827	809

Figure 4.5: 61-month clinic - Upper arch tooth condition

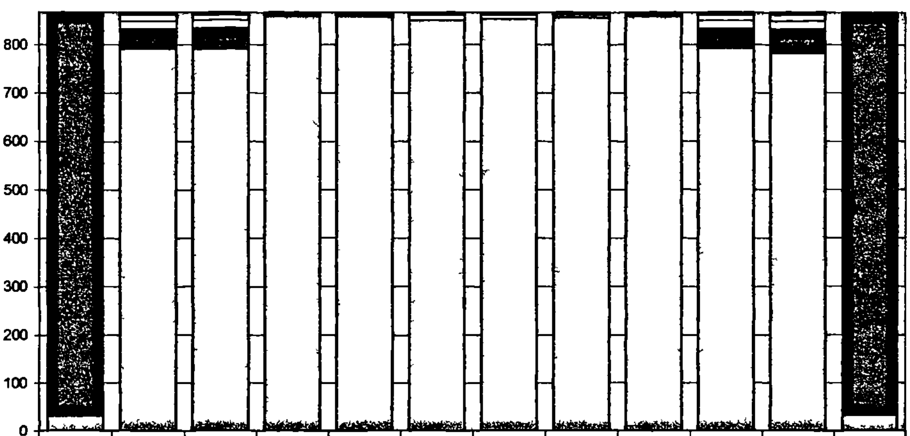
Right **Left**



	ur661	ure61	urd61	urc61	urb61	ura61	ula61	ulb61	ulc61	uld61	ule61	ul661
■ Not determined	3	5	5	5	5	4	4	5	5	5	5	3
■ Unerupted	835											842
□ Filled		9	6			4				7	18	
□ Missing		11	9	1	5	13	13	4	1	9	11	
■ Decayed		58	26	3	10	16	10	3	4	22	44	
■ Erupted and sound	29	784	821	858	847	830	840	855	857	824	789	22

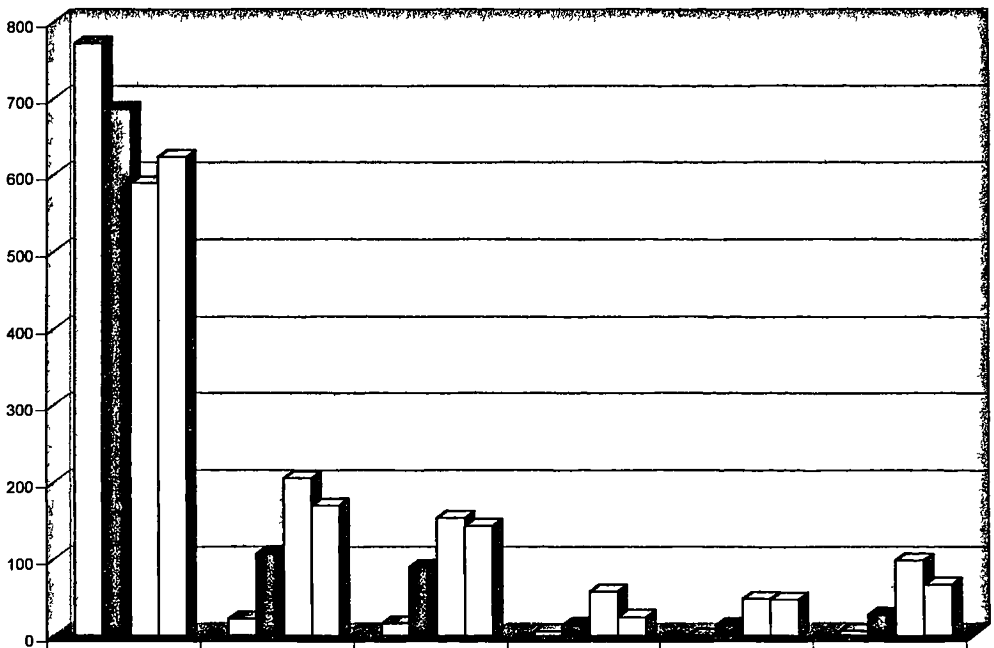
Figure 4.6: 61-month clinic - Lower arch tooth condition

Right **Left**



	lr661	lre61	lrd61	lrc61	lrb61	lra61	lla61	llb61	llc61	lld61	lle61	ll661
■ Not determined	3	5	5	5	5	5	5	5	5	5	5	3
■ Unerupted	833											831
□ Filled		14	11					1	1	12	14	
□ Missing		15	16		3	10	9	5		16	15	
■ Decayed		42	44	2				1	1	41	51	
■ Erupted and sound	31	791	791	860	859	852	853	856	860	793	782	33

Figure 4.7: Distribution of the number of children with caries experience and the treatment received at the 31-, 43- and 61-month clinics



	dmft=0	dmft>0	dt>0	mt>0	ft>0	mft>0
■ 31-month clinic	771	22	16	6	0	6
■ 43-month	686	107	90	14	13	27
□ 61-month (all teeth)	588	205	154	57	48	98
□ 61-m (no incisors)	623	170	144	24	47	66

Key:

dmft=0	Caries-free
dmft>0	Evidence of caries experience
dt>0	Untreated caries present
mt>0	Teeth missing (extracted)
ft>0	Restored teeth present
mft>0	Sum of cases with restored and extracted teeth

CHAPTER 5

THE INFLUENCE OF SOCIO-DEMOGRAPHIC FACTORS ON THE CARIES EXPERIENCE OF THE STUDY GROUP

5.1 Introduction

The association between dental caries and social background is well documented. Those children from lower socio-economic groups have a greater caries experience compared with those in the higher groups (Silver 1982, 1987, Hinds and Gregory 1994).

The information held by ALSPAC regarding socio-demographic factors of the cohort includes home ownership status, the highest educational level of the mother and maternal age at delivery. These three factors were compared with the caries experience (dmft) of the 867 children who attended the 31-, 43- and 61-month clinics in order to determine whether there was an association between each of the social factors and the level of caries seen in the study children.

The null hypothesis (1) tested was that there is no association between the home ownership status, maternal age at delivery, educational level of the mother and the caries experience of the children.

5.2 Results

5.2.1 Home ownership status

The distribution of parental home ownership status is given in Table 5.1.

In order to produce groups containing a sufficient number of cases to produce meaningful analysis, the home ownership status was combined into two groups. These were:

a. Mortgaged or owned

b. Council or rented.

The results of the combined categories are given in Table 5.2 with 83% of the children living in mortgaged or owned property. Using the Chi-squared test for trend (χ^2), the two home ownership groups were analysed to demonstrate the proportion of children within each home ownership group who had a history of caries experience. The caries experience (dmft), decayed (dt), missing (mt) and filled (ft) components and the restorative index (mft) of the children were compared.

If data were missing then the case was eliminated from analysis, which accounts for slight discrepancies in the figures produced for each clinic.

The *dmft* was calculated using all primary teeth at 31-, 43- and 61-months of age.

5.2.1.1 Home ownership status compared with the caries experience (dmft) at the 31-, 43- and 61-month clinics

There was no statistically significant association between the proportion of children with caries experience in each of the home ownership groups at the 31-month clinic (p=0.064, Table 5.3). However there was a trend for more children within the council or rented group to have caries. A similar trend was found at the 43-month clinic with 17.6% of the children who lived in council or rented accommodation having a dmft>0, although no significant association was demonstrated (p=0.145). However there was a significant association between those children with caries experience at the 61-month clinic and their home ownership status (p=0.005). Those living in council or rented accommodation (16.4%) had a higher incidence of caries (35.9%) than those living in mortgaged or owned property (24.6%).

5.2.1.2 Home ownership status compared with the decayed component (dt) at the 31-, 43- and 61-month clinics

When the home ownership status was compared with the untreated caries (dt) at the 31-, 43- and 61-month clinics (Table 5.4), highly significant associations were demonstrated between the children's accommodation and the proportion with untreated caries at all three clinics ($p \leq 0.03$). Children living in council or rented property had significantly more untreated caries than those in mortgaged or owned housing.

5.2.1.3 Home ownership status compared with the missing component (mt) at the 31-, 43- and 61-month clinics

There was no significant association between home ownership status and the proportion of children with missing teeth (mt) at any of the clinics ($p \geq 0.143$, Table 5.5). However, at the 61-month clinic the trend was for more extractions to have been experienced by those in council accommodation with 10.3% missing teeth compared with only 6.8% of those in mortgaged or owned accommodation.

5.2.1.4 Home ownership status compared with the filled component (ft) at the 31-, 43- and 61-month clinics

No association was demonstrated between the proportion of children within each home ownership group, who had received restorative treatment at each of the clinics ($p \geq 0.626$, Table 5.6). No restorations had been placed at the 31-month clinic and therefore no χ^2 or p values could be calculated. Although not statistically significant, at the 61-month clinic slightly more children in the council or rented group (6.9%) had received restorative care than in the mortgaged or owned group (5.8%).

5.2.1.5 Home ownership status compared with the restorative index (mft) at the 31-, 43- and 61-month clinics

There were no significant associations between the proportion of children within each home ownership group who had received treatment at each of the three clinics ($p \geq 0.107$, Table 5.7). However, at the 61-month clinic a greater proportion of children in council or rented accommodation (16.6%) had received treatment than those in mortgaged or owned (11.7%) accommodation.

5.2.2 Maternal education

The level of maternal education ranged from GCSE to degree level (Table 5.8). For purposes of analysis these were combined into two larger groups. These were

a. Up to GCSE 'O-level' standard

b. Further or higher education

The majority of the mothers (55.4%) were educated to GCSE 'O-level' standard. The remaining 42.3% had received further education (Table 5.9).

The two educational groups were compared with the caries experience (dmft) and the decayed (dt), missing (mt), filled (ft) components and restorative indices (mft) of the children at each clinic.

5.2.2.1 Maternal education compared with the caries experience (dmft) at the 31-, 43- and 61-month clinics

A statistically significant association was found between education and the proportion of children with caries experience at the 31-month clinic ($p=0.043$, Table 5.10). A larger proportion of the children whose mothers had been educated to O-level standard had caries (3.4%) than those whose mothers had received higher education (1.1%). No significant association was demonstrated between the caries experience of each group at the 43- or 61-month clinic ($p \geq 0.316$). However, the trend at both clinics was for the greater caries experience to be in those children whose mothers completed their education to GCSE O-level standard or below.

5.2.2.2 Maternal education compared with the decayed component (dt) at the 31-, 43- and 61-month clinics

No significant association was demonstrated between the level of maternal education and the proportion of children with untreated caries at the 31-, 43- and 61-month clinics ($p \geq 0.061$, Table 5.11). The proportion of children with untreated caries was similar in both educational groups, although at the 31- and

61-month clinics there were slightly more children with untreated caries in the lower maternal education group.

5.2.2.3 Maternal education compared with the missing component (mt) at the 31-, 43- and 61-month clinics

No association was evident between the proportion of children who had experienced tooth extraction within the two educational groups at the 31-, 43- and 61-month clinics ($p \geq 0.557$, Table 5.12).

5.2.2.4 Maternal education compared with the filled component (ft) at the 31-, 43- and 61-month clinics

There was no association between the proportion of children who had received restorative care in each educational group at any of the clinics ($p \geq 0.617$, Table 5.13). No restorations were recorded at the 31-month clinic and no obvious trend in uptake of restorative care could be seen at either the 43- or 61-month clinics.

5.2.2.5 Maternal education compared with the restorative index (mft) at the 31-, 43- and 61-month clinics

No association was demonstrated between the educational group of the mother and the treatment received by the children (mft) at the three clinics ($p \geq 0.636$, Table 5.14). The proportion of children who had received treatment of any kind in both groups was remarkably similar at each clinic.

5.2.3 Maternal age at delivery

Maternal age at delivery ranged from 16 to 43 years of age (Table 5.15). The ages were combined into two groups in order to produce groups with sufficient cases to allow statistical analysis. These were:

a. Sixteen to twenty-nine years

b. Thirty years or more

The proportion of children in each group was similar, with 52.7% within the younger group and 47.3% in the older group (Table 5.16).

Preliminary analysis was carried out using groups with a maternal age range from 16-25 and 25 years or more. The results were similar to those reported here.

Maternal age was compared with the caries experience (dmft) and the decayed (dt), missing (mt), filled (ft) components and restorative indices (mft) for each clinic.

5.2.3.1 Maternal age at delivery compared with the caries experience (dmft) at the 31-, 43- and 61-month clinics

No significant association was found between the proportion of children with caries experience (dmft) in either group at the 31-, 43- or the 61-month clinics ($p \geq 0.284$, Table 5.17). No obvious trend in caries experience could be determined between the children born to older or younger mothers.

5.2.3.2 Maternal age at delivery compared with the decayed component (dt) at the 31-, 43- and 61-month clinics

No significant associations were demonstrated between the proportion of children with untreated caries and maternal age at the 31-, 43- or 61-month clinics ($p \geq 0.088$, Table 5.18). Despite this, slightly more of the children born to the younger mothers (13.4%) had untreated caries than those born to older mothers (9.6%) at the 43- and 61-month clinics (20.1% and 19.8% respectively).

5.2.3.3 Maternal age at delivery compared with the missing component (mt) at the 31-, 43- and 61-month clinics

There was no significant association between the proportion of children who had experienced tooth extraction (mt) and maternal age at the 31-, 43- and 61-month clinics ($p \geq 0.497$, Table 5.19). Although no clear trends could be observed, at 61-months slightly more children had missing teeth in the older maternal age group (8.3%) than the younger group (7.1%).

5.2.3.4 Maternal age at delivery compared with the filled component (ft) at the 31-, 43- and 61-month clinics

At 43-months, a significant association was demonstrated between the proportion of children who had received restorative treatment within the two maternal age groups ($p=0.016$, Table 5.20), with more children (2.8%) born to older mothers having received restorations than the younger group (0.7%). No statistics were computed for the filled component at the 31-month clinic as no restorations had been placed. At 61-months of age, there was no association between the groups ($p=0.510$), although the trend appeared to indicate that more restorations were placed in children of older mothers (6.6%) compared with those in the younger group (5.5%).

5.2.3.5 Maternal age at delivery compared with the restorative index (mft) at the 31-, 43- and 61-month clinics

No significant association could be demonstrated between the proportion of children who had received restorative care and maternal age at the 31-, 43- or 61-month clinics ($p \geq 0.095$, Table 5.21). However, at the 43- and 61-month clinics a greater proportion of children who had experienced extractions or restorations were in the older maternal age group.

5.3 Summary of the observed effects of socio-demographic factors on the caries experience and treatment received at the 31-, 43- and 61-month clinics

The null hypothesis (1) is rejected. Socio-demographic factors are associated with the caries experience of this study group. The strongest associations were observed in the caries experience and untreated caries of the children who lived in council or rented property. Where no significant associations were demonstrated, there were clear trends towards a larger proportion of the children receiving care in those living in council or rented property than in those in mortgaged or owned property. If the sample size had been larger, then these trends would have had greater power and it is likely that these factors would have reached statistical significance.

The children whose mothers had been educated to O-level standard or lower had a tendency toward increased caries experience and untreated caries, although the differences between the two groups were not significant. There were no clear trends in the uptake of care between the groups.

No clear trends were seen within the two maternal age groups and the caries experience, although a significantly greater proportion of children born to older mothers ($p=0.016$) had received treatment in the form of fillings at 43-months.

Therefore in this study group, children who lived in council or rented property and whose mothers were educated up to O-level standard had a greater tendency to have experienced caries. Older mothers were more likely to have sought restorative treatment for their children.

Table 5.1: Home ownership status

Home ownership	n	%	Valid %
Mortgaged	692	79.8	81.2
Owned	15	1.7	1.8
Rented:			
Council	76	8.8	8.9
Private, furnished	25	2.9	2.9
Private, unfurnished	14	1.6	1.6
Housing Association	8	0.9	0.9
Other	22	2.5	2.6
Total	852	98.3	100
Not specified	15	1.7	
Total	867	100	

Table 5.2: Modification of home ownership status

Home ownership	n	%	Valid %
Owned or mortgaged	707	81.5	83.0
Council or rented	145	16.7	17
Total	852	98.3	100
Not specified	15	1.7	
Total	867	100	

Table 5.3: Proportion of children within each home ownership group by proportion of children with caries experience (dmft>0) at the 31-, 43- and 61-month clinics

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
dmft31	n=799 100.0%	668	83.6%	131	16.4%	4	0.064+
	dmft=0 778 (97.4%)	654	97.9%	124	94.7%		
	dmft>0 21 (2.6%)	14	2.1%	7	5.3%		
dmft43	n=828 100.0%	686	82.9%	142	17.1%	2	0.145NS
	dmft=0 714 (86.2%)	597	87.0%	117	82.4%		
	dmft>0 114 (13.8%)	89	13.0%	25	17.6%		
dmft61	n=847 100.0%	702	82.9%	145	17.1%	8	0.005**
	dmft=0 622 (73.4%)	529	75.4%	93	64.1%		
	dmft>0 225 (26.6%)	173	24.6%	52	35.9%		

+ Fisher's exact test ** $p<0.01$ NS $p>0.05$

Table 5.4: Proportion of children within each home ownership group by proportion of children with untreated caries (dt>0) at the 31-, 43- and 61-month clinics

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
dt31	n=799 100.0%	668	83.6%	131	16.4%	9	0.009+**
	dt=0 783 (98%)	659	98.7%	124	94.7%		
	dt>0 16 (2%)	9	1.3%	7	5.3%		
dt43	n=828 100.0%	686	82.9%	142	17.1%	5	0.03*
	dt=0 732 (88.4%)	614	89.5%	118	83.1%		
	dt>0 96 (11.6%)	72	10.5%	24	16.9%		
dt61	n=847 100.0%	702	82.9%	145	17.1%	8	0.005**
	dt=0 679 (80.2%)	575	81.9%	104	71.7%		
	dt>0 168 (19.8%)	127	18.1%	41	28.3%		

+ Fisher's exact test ** $p< 0.01$ * $p<0.05$

Table 5.5: Proportion of children within each home ownership group by proportion of children with missing teeth (mt>0) at the 31-, 43- and 61-month clinics

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
mt31	n=799 100.0%	668	83.6%	131	16.4%	0.8	1.000+ NS
	mt=0 795 (99.5%)	664	99.4%	131	100.0%		
	mt>0 4 (0.5%)	4	0.6%	0	0.0%		
mt43	n=828 100.0%	686	82.9%	142	17.1%	0.08	1.000+ NS
	mt=0 814 (98.3%)	674	98.3%	140	98.6%		
	mt>0 14 (1.7%)	12	1.7%	2	1.4%		
mt61	n=847 100.0%	702	82.9%	145	17.1%	2	0.143NS
	mt=0 784 (92.6%)	654	93.2%	130	89.7%		
	mt>0 63 (7.4%)	48	6.8%	15	10.3%		

+ Fisher's exact test NS p>0.05

Table 5.6: Proportion of children within each home ownership group by proportion of children with restored teeth (ft>0) at the 31-, 43- and 61-month clinics

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
ft31	n=799 100.0%	668	83.6%	131	16.4%	xx	xx
	ft=0 799 (100%)	668	100.0%	131	100.0%		
	ft>0 (0%)	0	0.0%	0	0.0%		
ft43	n=828 100.0%	686	82.9%	142	17.1%	0.08	1.000 $^{+NS}$
	ft=0 814 (98.3%)	674	98.3%	140	98.6%		
	ft>0 14 (1.7%)	12	1.7%	2	1.4%		
ft61	n=847 100.0%	702	82.9%	145	17.1%	0.2	0.626 ^{NS}
	ft=0 796 (94%)	661	94.2%	135	93.1%		
	ft>0 51 (6%)	41	5.8%	10	6.9%		

+ Fisher's exact test xx No statistics computed as ft31 is a constant ^{NS} p>0.05

Table 5.7: Proportion of children within each home ownership group by proportion of children who had received treatment (mft>0) at the 31-, 43- and 61-month clinics

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
mft31	n=799 100.0%	668	83.6%	131	16.4%	0.8	1.000^{+NS}
	mft=0 795 (99.5%)	664	99.4%	131	100.0%		
	mft>0 4 (0.5%)	4	0.6%	0	0.0%		
mft43	n=828 100.0%	686	82.9%	142	17.1%	0.2	1.000^{+NS}
	mft=0 800 (96.6%)	662	96.5%	138	97.2%		
	mft>0 28 (3.4%)	24	3.5%	4	2.8%		
mft61	n=847 100.0%	702	82.9%	145	17.1%	3	0.107^{NS}
	mft=0 741 (87.5%)	620	88.3%	121	83.4%		
	mft>0 106 (12.5%)	82	11.7%	24	16.6%		

$^{+}$ Fisher's exact test ^{NS} p>0.05

Table 5.8: Maternal educational level

Maternal educational level	n	%	Valid %
CSE Vocational O level A level Degree	89 81 310 241 126	10.3 9.3 35.8 27.8 14.5	10.5 9.6 36.6 28.5 14.9
Total	847	97.7	100
Not specified	20	2.3	
Total	867	100	

Table 5.9: Modification of maternal educational level

Maternal educational level	n	%	Valid %
O level or below A level or higher	480 367	55.4 42.3	56.7 43.3
Total	847	97.7	100
Not specified	20	2.3	
Total	867	100	

Table 5.10: Proportion of children within each maternal education group by proportion of children with caries experience (dmft>0) at the 31-, 43- and 61-month clinics

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
dmft31	n=795 100.0%	447	56.2%	348	43.8%	4	0.043*
	dmft=0 776 (97.6%)	432	96.6%	344	98.9%		
	dmft>0 19 (2.4%)	15	3.4%	4	1.1%		
dmft43	n=822 100.0%	465	56.4%	357	43.4%	0.2	0.649^{NS}
	dmft=0 711 (86.5%)	400	86.0%	311	87.1%		
	dmft>0 111 (13.5%)	65	14.0%	46	12.9%		
dmft61	n=842 100.0%	476	56.5%	366	43.5%	1	0.316^{NS}
	dmft=0 618 (73.4%)	343	72.1%	275	75.1%		
	dmft>0 224 (26.6%)	133	27.9%	91	24.9%		

* $p<0.05$ ^{NS} $p>0.05$

Table 5.11: Proportion of children within each maternal education group by proportion of children with untreated caries (dt>0) at the 31-, 43- and 61-month clinics

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
dt31	n=795 100.0%	447	56.2%	348	43.8%	4	0.061 NS
	dt=0 780 (98.1%)	435	97.3%	345	99.1%		
	dt>0 15 (1.9%)	12	2.7%	3	0.9%		
dt43	n=822 100.0%	465	56.4%	357	43.4%	0.2	0.892 NS
	dt=0 729 (88.7%)	413	88.8%	316	88.5%		
	dt>0 93 (11.3%)	52	11.2%	41	11.5%		
dt61	n=842 100.0%	476	56.5%	366	43.5%	1	0.239 NS
	dt=0 677 (80.4%)	376	79.0%	301	82.2%		
	dt>0 165 (19.6%)	100	21.0%	65	17.8%		

+ Fisher's exact test NS $p>0.05$

Table 5.12: Proportion of children within each maternal education group by proportion of children with missing teeth (mt>0) at the 31-, 43- and 61-month clinics

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
mt31	n=795 100.0%	447	56.2%	348	43.8%	0.6	0.636 +NS
	mt=0 791 (99.5%)	444	99.3%	347	99.7%		
	mt>0 4 (0.5%)	3	0.7%	1	0.3%		
mt43	n=822 100.0%	465	56.4%	357	43.4%	0.3	0.557 NS
	mt=0 808 (98.3%)	456	98.1%	352	98.6%		
	mt>0 14 (1.7%)	9	1.9%	5	1.4%		
mt61	n=842 100.0%	476	56.5%	366	43.5%	0.002	0.962 NS
	mt=0 778 (92.4%)	440	92.4%	338	92.3%		
	mt>0 64 (7.6%)	36	7.6%	28	7.7%		

+ Fisher's exact test NS p>0.05

Table 5.13: Proportion of children within each maternal education group by proportion of children with restored teeth (ft>0) at the 31-, 43- and 61-month clinics

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
ft31	n=795 100.0%	447	56.2%	348	43.8%	xx	xx
	ft=0 795 (100%)	447	100.0%	348	100.0%		
	ft>0 (0%)	0	0.0%	0	0.0%		
ft43	n=822 100.0%	465	56.4%	357	43.4%	0.3	0.617 [NS]
	ft=0 808 (98.3%)	458	98.5%	350	98.0%		
	ft>0 14 (1.7%)	7	1.5%	7	2.0%		
ft61	n=842 100.0%	476	56.5%	366	43.5%	0.1	0.733 [NS]
	ft=0 791 (93.9%)	446	93.7%	345	94.3%		
	ft>0 51 (6.1%)	30	6.3%	21	5.7%		

xx No statistics computed as ft31 is a constant [NS] p value not significant p>0.05

Table 5.14: Proportion of children within each maternal education group by proportion of children who had received treatment (mft>0) at the 31-, 43- and 61-month clinics

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
mft31	n=795 100.0%	447	56.2%	348	43.8%	0.6	0.636+NS
	mft=0 791 (99.5%)	444	99.3%	347	99.7%		
	mft>0 4 (0.5%)	3	0.7%	1	0.3%		
mft43	n=822 100.0%	465	56.4%	357	43.4%	0.004	0.950 NS
	mft=0 794 (96.6%)	449	96.6%	345	96.6%		
	mft>0 28 (3.4%)	16	3.4%	12	3.4%		
mft61	n=842 100.0%	476	56.5%	366	43.5%	0.1	0.753 NS
	mft=0 735 (87.3%)	414	87.0%	321	87.7%		
	mft>0 107 (12.7%)	62	13.0%	45	12.3%		

+ Fisher's exact test NS $p>0.05$

Table 5.15: Maternal age at delivery

Maternal age	n	%	Valid %
16.00	1	0.1	0.1
17.00	1	0.1	0.1
18.00	2	0.2	0.2
19.00	9	1.0	1.0
20.00	7	0.8	0.8
21.00	14	1.6	1.6
22.00	18	2.1	2.1
23.00	24	2.8	2.8
24.00	31	3.6	3.6
25.00	54	6.2	6.2
26.00	59	6.8	6.8
27.00	70	8.1	8.1
28.00	77	8.9	8.9
29.00	89	10.3	10.3
30.00	85	9.8	9.8
31.00	58	6.7	6.7
32.00	66	7.6	7.6
33.00	55	6.3	6.3
34.00	39	4.5	4.5
35.00	28	3.2	3.2
36.00	21	2.4	2.4
37.00	23	2.7	2.7
38.00	15	1.7	1.7
39.00	6	0.7	0.7
40.00	7	0.8	0.8
41.00	3	0.3	0.3
42.00	3	0.3	0.3
43.00	1	0.1	0.1
Not specified	1	0.1	
Total	867	100	100

Table 5.16: Modified maternal age at delivery

Maternal age	n	%	Valid %
16-29	456	52.6	52.7
29+	410	47.3	47.3
Not specified	1	0.1	
Total	867	100	100

Table 5.17: Proportion of children within each maternal age group by proportion of children with caries experience (dmft>0) at the 31-, 43- and 61-month clinics

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	value
dmft31	n=813 100.0%	432	53.1%	381	46.9%	0.3	0.608 [NS]
	dmft=0 792 (97.4%)	422	97.7%	370	97.7%		
	dmft>0 21 (2.6%)	10	2.3%	11	2.9%		
dmft43	n=841 100.0%	447	53.2%	394	46.8%	1	0.284 [NS]
	dmft=0 725 (86.2%)	380	85.0%	345	87.6%		
	dmft>0 116 (13.8%)	67	15.0%	49	12.4%		
dmft61	n=861 100.0%	452	52.5%	409	47.5%	0.04	0.845 [NS]
	dmft=0 630 (73.2%)	332	73.5%	298	72.9%		
	dmft>0 231 (26.8%)	120	26.5%	111	27.1%		

[NS] p>0.05

Table 5.18: Proportion of children within each maternal age group by proportion of children with untreated caries (dt>0) at the 31-, 43- and 61-month clinics

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	p value
dt31	n=813 100.0%	432	53.1%	381	46.9%	0.6	0.447 NS
	dt=0 797 (98%)	425	98.4%	372	97.6%		
	dt>0 16 (2%)	7	1.6%	9	2.4%		
dt43	n=841 100.0%	447	53.2%	394	46.8%	3	0.088 NS
	dt=0 743 (88.4%)	387	86.6%	356	90.4%		
	dt>0 98 (11.6%)	60	13.4%	38	9.6%		
dt61	n=861 100.0%	452	52.5%	409	47.5%	0.01	0.904 NS
	dt=0 689 (80%)	361	79.9%	328	80.2%		
	dt>0 172 (20%)	91	20.1%	81	19.8%		

NS $p>0.05$

Table 5.19: Proportion of children within each maternal age group by proportion of children with missing teeth (mt>0) at the 31-, 43- and 61-month clinics

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	p value
mt31	n=813 100.0%	432	53.1%	381	46.9%	0.09	1.000 ^{NS}
	mt=0 808 (99.4%)	429	99.3%	379	99.3%		
	mt>0 5 (0.6%)	3	0.7%	2	0.5%		
mt43	n=841 100.0%	447	53.2%	394	46.8%	0.00	1.000 ^{NS}
	mt=0 826 (98.2%)	439	98.2%	387	98.2%		
	mt>0 15 (1.8%)	8	1.8%	7	1.8%		
mt61	n=861 100.0%	452	52.5%	409	47.5%	0.46	0.497 ^{NS}
	mt=0 795 (92.3%)	420	92.9%	375	91.7%		
	mt>0 66 (7.7%)	32	7.1%	34	8.3%		

^{NS} $p>0.05$

Table 5.20: Proportion of children within each maternal age group by proportion of children with restored teeth (ft>0) at the 31-, 43- and 61-month clinics

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	p value
ft31	n=813 100.0%	432	53.1%	381	46.9%	xx	xx
	ft=0 813 (100%)	432	100.0%	381	100.0%		
	ft>0 (0%)	0	0.00%	0	0.00%		
ft43	n=841 100.0%	447	53.2%	394	46.8%	6	0.016*
	ft=0 827 (98.3%)	444	99.3%	383	97.2%		
	ft>0 14 (1.7%)	3	0.7%	11	2.8%		
ft61	n=861 100.0%	452	52.5%	409	47.5%	0.4	0.510 NS
	ft=0 809 (94%)	427	94.5%	382	93.4%		
	ft>0 52 (6%)	25	5.5%	27	6.6%		

xx No statistics computed as ft31 is a constant * $p<0.05$ level NS $p>0.05$

Table 5.21: Proportion of children within each maternal age group by proportion of children who had received treatment (mft>0) at the 31-, 43- and 61-month clinics

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	p value
mft31	n=813 100.0%	432	53.1%	381	46.9%	0.09	1.000 NS
	mft=0 808 (99.4%)	429	99.3%	379	99.5%		
	mft>0 5 (0.6%)	3	0.7%	2	0.5%		
mft43	n=841 100.0%	447	53.2%	394	46.8%	3	0.095 NS
	mft=0 812 (96.6%)	436	97.5%	376	95.4%		
	mft>0 29 (3.4%)	11	2.5%	18	4.6%		
mft61	n=861 100.0%	452	52.5%	409	47.5%	1	0.240 NS
	mft=0 751 (87.2%)	400	88.5%	351	85.8%		
	mft>0 110 (12.8%)	52	11.5%	58	14.2%		

NS $p>0.05$

CHAPTER 6

THE INFLUENCE OF DIETARY HABITS ON DENTAL CARIES

6.1 Introduction

As the child gets older the diet expands, with new foods being introduced and the child eating more frequently (Rossow *et al.* 1990). The effects of dietary sugars and the relationship with caries are well documented (Section 1.3.2.2). The consistency and frequency of consumption are important factors in the development of dental caries (Gustaffson *et al.* 1954, Levine 1996).

Parents were asked to record the consumption of food types via self-completion questionnaires (Section 2.3) when the children were 6-, 15- and 24-months of age.

The dietary habits of the 867 children who attended the 31-, 43- and 61-month clinics are reported. The frequency of consumption of specified foods was compared with the caries experience of the group at the 31-, 43- and 61-month clinics.

No information regarding the consistency of food types or whether teeth were cleaned after consumption was obtained.

The null hypothesis (2) tested was that consumption of cariogenic foods is not significantly associated with the caries experience of the study group.

6.2 Results

Consumption was reported by the parents and this confirmed the introduction of new and varied foods at 6-, 15- and 24-months (Table 6.1).

At 6-months of age, 24% of the children had been given chocolate and 18% given biscuits, although only 1% had received sweets and crisps. More of the children had been given raw fruit (38%). By 15-months of age, these figures had increased substantially with 92% of children eating biscuits. Many more children were eating apples (79%) or other raw fruit (91%). The proportion of children consuming chocolate had increased to 79% and 28% had been given other confectionery. Very little difference was seen between the percentage of children receiving the foods at 15- and 24-months with the exception of crisps, which had increased from 62% to 90% and sweets, which increased from 28% to 72%.

Interestingly, despite the consumption of these potentially cariogenic, sugary foods and 34% of parents adding sugar to foods, 80% of parents reported deliberately selecting '*low sugar*' foods for the children at 15- and 24-months.

6.2.1 Proportion of children consuming specific foods at 6-, 15- and 24-months

The consumption of food types as reported in the 6-, 15- and 24-month questionnaires was compared using the Chi-squared test for trend (χ^2) (Tables 6.2 and 6.3). The tables show the trend in uptake of foods in greater detail than Table 6.1. The tables directly compare the data and determine whether there is a significant association between the proportion of children consuming the specified foods at the two ages. When the children were compared at 6- and 15-months, there was a significant association between the proportion of children eating biscuit, rusks, fruit, and chocolate ($p \leq 0.021$). However, this was not the case with cereals, sweets or crisps ($p \geq 0.074$). This may be due to parental reluctance to introduce foods that have a high sugar and salt content. The changes in the proportion of children receiving each food were all statistically significant between 15- and 24-months ($p \leq 0.011$).

6.2.2 Weekly consumption of specific foods at 6-, 15- and 24-months compared with the caries experience (dmft) at 31-, 43- and 61-months

The frequency of intake of the various foods was compared with the caries experience of the cohort at the 31- (dmft31), 43- (dmft43) and 61-month (dmft61) clinics, using the Mann-Whitney test for independent samples. This distribution-free test was used because the data regarding frequency of food consumption were skewed and therefore non-normally distributed. The median is presented in the Mann-Whitney tables (Tables 6.4 to 6.12). However, the mean consumption and standard deviations for each food are given in Appendix 56.

The *dmft* at 61-months included all primary teeth, since this allowed comparison between the increase in caries experience at 31-, 43 and 61-months. The *dmft* at 61-months, using only canines and molars was compared with the food types in a similar manner and no changes in significance were found and are not reported.

At the 31-month clinic, only 2.8% of the study group had a history of caries experience (dmft>0). The weekly consumption of each food at 6-, 15- and 24-months was compared with the caries experience at the 31-month clinic using the Mann-Whitney test (Tables 6.4, 6.5 and 6.6). No significant associations were found between caries experience (dmft31) and the frequency of consumption of any of the specified foods at 6-, 15- or 24-months ($p \geq 0.064$). By 24-months, all foods were being eaten more frequently.

At the 43-month clinic, the level of caries experience had increased to 13.5%. The weekly consumption of each food at 6-, 15- and 24-months was compared with the caries experience of the study group (dmft43) using the Mann-Whitney test (Tables 6.7, 6.8 and 6.9). A significant association was found between the frequency of consumption of chocolate at 15-months and caries experience at 43-months ($p=0.001$). Children with caries had a higher median consumption than those who were caries-free. Significant associations were also seen between the consumption of crisps and raw apple at 15-months ($p \leq 0.042$) in the children with and without caries at 43-months. The frequency with which sugar was added to the children's food at 15-months was also significantly higher in the children with caries (median 6.0) than those without (median 3.0) at 43-months ($p=0.001$). No other associations were evident ($p \geq 0.058$).

At the 61-month clinic, 25.9% of the children had caries (dmft>0). There was a strong association between the frequency of consumption of chocolate at 6-months ($p<0.0001$, Table 6.10) and 15-months ($p=0.006$, Table 6.11) and the caries experience at 61-months, but not at 24-months ($p=0.08$, Table 6.12). Associations were also found between the frequency of consumption of raw fruit other than apples at 24-months ($p=0.007$, Table 6.12), although in this case it was apparent that the children with the higher consumption of raw fruit were less likely to have caries. Consumption of cereals at 24-months was also significantly associated with caries experience ($p=0.009$), although the median consumption was the same for each group (7.0). No other significant associations were demonstrated ($p \geq 0.074$).

6.3 Summary of frequency of consumption of specified foods and the caries experience of the study group

The null hypothesis (2) is rejected. As one would expect, the foods known to be cariogenic (sweets, chocolate, and crisps) gave the strongest associations with the caries experience of the children ($p \leq 0.006$) and in each case these foods were more frequently consumed by the children with caries. Raw fruit consumption was also significantly associated with the caries experience of the cohort ($p=0.042$) and was eaten more frequently by the children who were caries-free. It may be that these children received fewer cariogenic foodstuffs such as biscuits and other confectionery, although this was not investigated further.

The proportion of children with caries at 31-months was small (2.8%) and no associations could be shown between the consumption of each food at 6-, 15- or 24-months and the caries experience of these children. The proportion of children with caries was greatest at the 61-month clinic (26.9%) and more associations were seen between caries and food consumption at this age than at 31- or 43-months. The frequency of chocolate consumption was greater in the children with caries at both 6- and 15-months.

Table 6.1: Percentage of the 867 study children consuming eating specific foods at 6-, 15- and 24-months

Food	6-months	15-months	24-months
Biscuits	18%	92%	92%
Plain rusks	60%	54%	7%
Other cereals	78%	48%	91%
Raw apple	N/A	79%	87%
Other raw fruit	38%	91%	90%
Chocolate	24%	79%	87%
Sweets	1%	28%	72%
Crisps	1%	62%	90%
Low sugar foods	N/A	81%	80%
Sugar added	N/A	N/A	34%

N/A Information not available

Table 6.2: Proportion of the 867 children consuming specific food types at 6- and 15-months (χ^2 test for trend)

Food type	n	Number of children eating				χ^2	p value
		Yes/n @ 6-months		Yes/n @ 15-months			
Biscuits	814	155	19%	793	97%	5	0.021^{+*}
Rusks	795	490	62%	463	58%	50	<0.0001
Other cereals at 6-m **BY** baby cereals at 15-m	796	642	81%	380	48%	0.7	0.417^{NS}
Raw fruit at 6-m **BY** raw apple at 15-m	811	326	40%	681	84%	17	<0.0001
Other raw fruit	813	327	40%	782	96%	10	0.002^{**}
Chocolate	811	198	24%	680	84%	33	<0.0001
Sweets	813	10	1%	245	30%	4	0.074^{+NS}
Crisps	813	13	2%	529	65%	2	0.239^{NS}

NS p>0.05 * p<0.05 ** p<0.01 +Fisher's exact test

Table 6.3: Proportion of the 867 children consuming specific food types at 15- and 24-months (χ^2 test for trend)

Food type	n	Number of children eating				χ^2	p value
		Yes/n @ 15-months		Yes/n @ 24-months			
Biscuits	798	777	97%	775	97%	20	0.002^{+**}
Rusks	763	442	58%	58	8%	23	<0.0001
Baby cereals at 15-m **BY** other cereals at 24-m	786	376	48%	758	96%	6	0.011^{*}
Raw apple	799	671	84%	726	91%	96	<0.0001
Other raw fruit	800	770	95%	760	96%	175	$<0.0001^{+}$
Chocolate	801	671	84%	730	91%	92	<0.0001
Sweets	800	237	30%	603	75%	55	<0.0001
Crisps	802	523	65%	755	94%	47	<0.0001

* p<0.05 ** p<0.01 +Fisher's exact test

Table 6.4: Frequency of intake of specified foods (per week) at 6-months compared with the caries experience of the cohort at the 31-month clinic (dmft31)

Foods at 6-m	dmft at 31-m	n	Median	U	p
Biscuits	No caries	822	0.0	6059	0.154 NS
	Caries present	17	0.0		
Plain rusks	No caries	803	1.0	6240	0.521 NS
	Caries present	17	2.0		
Sweetened rusks	No caries	814	0.0	6188	0.089 NS
	Caries present	18	0.0		
Other cereals	No caries	810	7.0	6380	0.574 NS
	Caries present	17	7.0		
Raw fruit	No caries	816	0.0	6363	0.263 NS
	Caries present	18	0.0		
Chocolate	No caries	806	0.0	5630	0.074 NS
	Caries present	17	0.0		
Sweets	No caries	827	0.0	7371	0.675 NS
	Caries present	18	0.0		
Crisps	No caries	825	0.0	7344	0.656 NS
	Caries present	18	0.0		

NS $p>0.05$ U Mann-Whitney test

Table 6.5: Frequency of intake of specified foods (per week) at 15-months compared with the caries experience of the cohort at the 31-month clinic (dmft31)

Foods at 15-m	dmft at 31-m	n	Median	U	p
Biscuits	No caries	735	6.0	5071	0.171 NS
	Caries present	17	7.0		
Rusks	No caries	436	0.0	1356	0.199 NS
	Caries present	8	0.0		
Raw apple	No caries	633	2.0	4404	0.625 NS
	Caries present	15	2.0		
Other raw fruit	No caries	728	4.0	6670	0.789 NS
	Caries present	19	4.0		
Chocolate	No caries	618	2.0	4133	0.249 NS
	Caries present	16	2.5		
Sweets	No caries	211	2.0	1039	0.541 NS
	Caries present	11	2.0		
Crisps	No caries	480	2.0	2304	0.822 NS
	Caries present	10	2.0		
Sugar added to food	No caries	201	3.0	664	0.064 NS
	Caries present	10	4.5		

NS $p>0.05$ U Mann-Whitney test

Table 6.6: Frequency of intake of specified foods (per week) at 24-months compared with the caries experience of the cohort at the 31-month clinic (dmft31)

Foods at 24-m	dmft at 31-m	n	Median	U	p
Biscuits	No caries	710	5.0	6178	0.528 NS
	Caries present	19	7.0		
Cereals	No caries	709	7.0	4934	0.095 NS
	Caries present	18	6.0		
Raw apple	No caries	674	2.5	4009	0.333 NS
	Caries present	14	2.125		
Other raw fruit	No caries	704	3.75	5057	0.778 NS
	Caries present	15	3.0		
Chocolate at	No caries	669	2.0	3253	0.117 NS
	Caries present	13	1.5		
Sweets	No caries	550	2.0	2051	0.165 NS
	Caries present	10	2.5		
Crisps	No caries	697	2.5	4988	0.760 NS
	Caries present	15	2.0		
Sugar added to food	No caries	250	2.5	955	0.205 NS
	Caries present	11	4.0		

NS $p>0.05$ U Mann-Whitney test

Table 6.7: Frequency of intake of specified foods (per week) at 6-months compared with the caries experience of the cohort at the 43-month clinic (dmft43)

Foods at 6-m	dmft at 43-m	n	Median	U	p
Biscuits	No caries	726	0.0	39653	0.387 NS
	Caries present	113	0.0		
Plain rusks	No caries	710	1.0	38542	0.816 NS
	Caries present	110	1.0		
Sweetened rusks	No caries	719	0.0	38281	0.137 NS
	Caries present	113	0.0		
Other cereals	No caries	716	7.0	39496	0.911 NS
	Caries present	111	7.0		
Raw fruit	No caries	721	0.0	38762	0.339 NS
	Caries present	113	0.0		
Chocolate	No caries	711	0.0	37631	0.185 NS
	Caries present	112	0.0		
Sweets	No caries	731	0.0	41637	0.941 NS
	Caries present	114	0.0		
Crisps	No caries	729	0.0	41464	0.837 NS
	Caries present	114	0.0		

NS $p>0.05$ U Mann-Whitney test

Table 6.8: Frequency of intake of specified foods (per week) at 15-months compared with the caries experience of the cohort at the 43-month clinic (dmft43)

Foods at 15-m	dmft at 43-m	n	Median	U	p
Biscuits	No caries	652	5.0	29087	0.073 NS
	Caries present	100	7.0		
Rusks	No caries	395	0.0	8818	0.227 NS
	Caries present	49	0.0		
Raw apple	No caries	554	2.0	22705	0.042 *
	Caries present	94	2.0		
Other raw fruit	No caries	644	4.0	32263	0.653 NS
	Caries present	103	4.0		
Chocolate	No caries	548	2.0	18349	0.001 ***
	Caries present	86	3.0		
Sweets	No caries	186	2.0	3038	0.358 NS
	Caries present	36	2.0		
Crisps	No caries	424	2.0	11889	0.041 *
	Caries present	66	2.0		
Sugar added to food	No caries	182	3.0	1683	0.001 ***
	Caries present	29	6.0		

NS $p>0.05$ * $p<0.05$ *** $p<0.001$ U Mann-Whitney test

Table 6.9: Frequency of intake of specified foods (per week) at 24-months compared with the caries experience of the cohort at the 43-month clinic (dmft43)

Foods at 24-m	dmft at 43-m	n	Median	U	p
Biscuits	No caries	622	5.12	31653	0.416 NS
	Caries present	107	5.0		
Cereals	No caries	626	7.0	28909	0.158 NS
	Caries present	101	7.0		
Raw apple	No caries	589	2.5	28065	0.549 NS
	Caries present	99	2.5		
Other raw fruit	No caries	619	3.75	29953	0.603 NS
	Caries present	100	4.0		
Chocolate	No caries	589	2.0	26056	0.448 NS
	Caries present	93	2.0		
Sweets	No caries	470	2.0	18807	0.094 NS
	Caries present	90	2.0		
Crisps	No caries	610	2.5	29205	0.320 NS
	Caries present	102	2.5		
Sugar added to food	No caries	223	2.0	3325	0.058 NS
	Caries present	37	3.75		

NS $p>0.05$ U Mann-Whitney test

Table 6.10: Frequency of intake of specified foods (per week) at 6-months compared with the caries experience of the cohort at the 61-month clinic (dmft61)

Foods at 6-m	dmft at 61-m	n	Median	U	p
Biscuits	No caries	613	0.0	68962	0.881 NS
	Caries present	226	0.0		
Plain rusks	No caries	602	1.0	63470	0.448 NS
	Caries present	218	1.0		
Sweetened rusks	No caries	608	0.0	67253	0.679 NS
	Caries present	224	0.0		
Other cereals	No caries	607	7.0	65089	0.548 NS
	Caries present	220	6.0		
Raw fruit	No caries	611	0.0	64288	0.151 NS
	Caries present	223	0.0		
Chocolate	No caries	600	0.0	58673	<0.0001
	Caries present	223	0.0		
Sweets	No caries	618	0.0	70081	0.907 NS
	Caries present	227	0.0		
Crisps	No caries	615	0.0	69871	0.670 NS
	Caries present	228	0.0		

NS p>0.05 U Mann-Whitney test

Table 6.11: Frequency of intake of specified foods (per week) at 15-months compared with the caries experience of the cohort at the 61-month clinic (dmft61)

Foods at 15-m	dmft at 61-m	N	Median	U	p
Biscuits	No caries	560	5.0	49579	0.097 NS
	Caries present	192	7.0		
Rusks	No caries	339	0.0	16825	0.313 NS
	Caries present	105	0.0		
Raw apple	No caries	477	2.0	37646	0.127 NS
	Caries present	171	2.0		
Other raw fruit	No caries	555	4.0	52565	0.779 NS
	Caries present	192	4.0		
Chocolate	No caries	458	2.0	34745	0.006**
	Caries present	176	2.0		
Sweets	No caries	158	2.0	4876	0.663 NS
	Caries present	64	2.0		
Crisps	No caries	361	2.0	21963	0.318 NS
	Caries present	129	2.0		
Sugar added to food	No caries	146	3.0	4419	0.416 NS
	Caries present	65	4.0		

NS p>0.05 ** p<0.01 U Mann-Whitney test

Table 6.12: Frequency of intake of specified foods (per week) at 24-months compared with the caries experience of the cohort at the 61-month clinic (dmft61)

Foods at 24-m	dmft at 61-m	N	Median	U	p
Biscuits	No caries	537	5.0	50903	0.794 NS
	Caries present	192	5.0		
Cereals	No caries	539	7.0	44354	0.009**
	Caries present	188	7.0		
Raw apple	No caries	499	2.5	42835	0.062 NS
	Caries present	189	2.5		
Other raw fruit	No caries	538	4.0	42267	0.007**
	Caries present	181	3.0		
Chocolate	No caries	506	2.0	40605	0.060 NS
	Caries present	176	2.0		
Sweets	No caries	400	2.0	29737	0.188 NS
	Caries present	160	2.0		
Crisps	No caries	520	2.0	46578	0.168 NS
	Caries present	192	2.5		
Sugar added to food	No caries	184	2.5	6893	0.858 NS
	Caries present	76	2.25		

NS p>0.05 ** p<0.01 U Mann-Whitney test

CHAPTER 7

THE INFLUENCE OF DRINKING HABITS ON DENTAL EROSION

7.1 Introduction

Acidic and carbonated drinks have been shown to contribute toward enamel and dentine erosion, particularly in the anterior region (Millward *et al.* 1994a, Zero 1996). Few studies have looked at the longitudinal dietary intake of children from a young age and its effects on the primary dentition. The Child Dental Health Survey (O'Brien 1994) recorded erosion in children at 5 years of age whilst the National Diet and Nutrition Survey (Hinds and Gregory 1995) looked at a cross-section of 1.5 to 4.5 year olds in 1992-1993.

The presence of erosion in the primary dentition was recorded. The four upper incisors and lower first molars of the 867 children at 61-months were examined (Section 2.5.4). The parents reported the drinking habits of the children at 6-, 15- and 24-months of age (Section 2.3). Data included the weekly frequency of consumption of carbonated and non-carbonated drinks. Information about the manner in which the drink was consumed was not obtained. No record was made of the time taken for the child to finish the drink, whether a straw was used, whether cordials were diluted or whether drinks were *'low sugar'* or *'sugar-free'* products. However, 80% of parents reported deliberately choosing *'low sugar'* products.

The upper incisor teeth erupt from around 6-months of age and therefore little or no effect is likely to be caused by drinks at this age. However, it is likely that early drinking habits will be continued and therefore analysis was carried out on data from the 6-, 15- and 24-month questionnaires.

The information was compared with modified data produced from the clinical observation of dental erosion on the upper incisors and lower first molar teeth of the children at 61-months (Section 2.8.5).

The null hypothesis (3) tested was that consumption of acidogenic fruit drinks is not associated with erosion in the primary dentition of these children.

7.2 Results

7.2.1 Incidence of dental erosion

The examiners had quantified the dental erosion on the upper incisors and lower first molars using codes for the depth and area of the erosion affecting each tooth. Due to the small number of children with erosion, the data were modified (Section 2.8.5) and divided into four categories. These were:

1. Any evidence of erosion on the upper incisors or the lower first molars
2. Palatal incisor erosion
3. Labial incisor erosion
4. Molar (occlusal) erosion

Overall, 270 of the 867 cases (31%) showed some evidence of erosion, on either the upper incisors or lower first molar teeth. Palatal incisor erosion was reported in 264 cases (30% of the group), labial incisor erosion in 31 cases (4%) and molar erosion in 17 (2%) cases (Table 7.1).

7.2.2 Consumption of soft drinks

Parents reported whether the children were given drinks as specified in the 6-, 15- and 24-month questionnaires and if so they recorded the weekly consumption. The specified drinks were:

- Cola
- Other carbonated drinks
- Apple juice
- Blackcurrant juice or rosehip syrup
- Other fruit juice (15- and 24-months only)
- Other fruit drink

As the children got older, more of them received a wider range of drinks as the diet expanded to include the food and drink consumed by the rest of the family (Table 7.2). Few drank carbonated drinks at 6-months, but by 24-months 50% of the children had experienced carbonated drinks and fruit drinks (juice or squash) were given to around 75% of the children.

7.2.2.1 Proportion of children consuming specific drinks at 6-, 15- and 24-months

The Chi-squared test for trend (χ^2) was used to compare the consumption of specific drinks reported in the 6-, 15- and 24-month questionnaires (Tables 7.3 and 7.4). The tables show the trend in consumption of the drinks as the child got older. The 6-month questionnaire had not differentiated between fruit juice or fruit drink. Therefore, the consumption of fruit drinks at 6-months was compared with the consumption of fruit drinks and fruit juices at 15-months.

As expected, the proportion of children drinking each drink increased significantly with time. The proportion of children having either cola or other carbonated drinks at 6-months was small (1%) but increased to 20% at 15-months (Table 7.3) and to 47% at 24-months (Table 7.4). The proportion of children drinking non-carbonated drinks at 6-months was greater than those drinking carbonated drinks with 23% drinking apple juice and 55% drinking other fruit drinks. At 24-months, 81% were drinking fruit drinks.

Strong associations were demonstrated between the proportion of children drinking cola, apple juice and blackcurrant or rosehip drinks at 6- and 15-months ($p<0.0001$). There were also significant associations between those drinking fruit drinks at 6-months and fruit juices at 15-months ($p<0.0001$) and between those drinking other fruit drinks at both ages ($p=0.024$). In each case there was a substantial increase in the proportion of children drinking each drink at the older age. No association was demonstrated between the children who consumed other carbonated drinks at 6- and 15-months ($p=0.118$). Only six children had consumed these drinks at 6-months. Three of these children were reported as no longer drinking carbonated drinks at 15-months, although they were drinking them again at 24-months. This could be due to an error in reporting by the carer or a misunderstanding of the question posed.

Highly significant associations were evident between the proportion of children drinking each drink (carbonated and non-carbonated) at 15- and 24-months ($p<0.0001$). There were more children drinking each drink at 24-months with the exception of blackcurrant or rosehip drinks which decreased from 57% to 49% and apple juice which decreased from 48% to 45%. The greatest increase was in the proportion of children drinking carbonated drinks, from 20% at 15-months to around 50% at 24-months.

7.2.2.2 Summary of results of comparison between consumption of drinks at 6-, 15- and 24-months

The strong associations seen suggest that, once started, the children continued to receive each drink. There was a significant increase in the number of children receiving these drinks at each time-point, particularly carbonated drinks, with the exception of blackcurrant juice or rosehip drink and apple juice, which decreased.

7.2.3 Comparison between the site of erosion and the frequency of consumption of drinks at 6-, 15- and 24-months

It is well documented that the frequency of consumption of acidic drinks (both carbonated and non-carbonated) is an important aetiological factor in dental erosion (Millward *et al.* 1994a, Zero 1996).

Further analysis involved the comparison of the weekly consumption of each drink at 6-, 15- and 24-months with the site of erosion. In addition, the weekly intake was summed to produce the total consumption of the drink types from the 24-month questionnaire in the following way:

- Total weekly consumption of carbonated drinks at 24-months
- Total weekly consumption of non-carbonated drinks at 24-months
- Total weekly consumption of carbonated and non-carbonated drinks at 24-months

The frequency of drink consumption by the children produced skewed, non-normally distributed data. Therefore the Mann-Whitney non-parametric test for independent samples was used to compare drink consumption with the presence or absence of erosion in the children. The median is presented in the Mann-Whitney tables. However the mean and standard deviations of consumption of each drink are given in Appendix 7.

7.2.3.1 Any evidence of erosion

There was no significant association between the median consumption of any of the drinks at 6-months in the children with or without erosion ($p \geq 0.154$, Table 7.5).

A strong statistical association was demonstrated between the consumption of other fruit drinks at 15-months and the presence of erosion ($p=0.002$, Table 7.6). The median consumption of the children with erosion was 4.0 and of those without was 2.0. No significant association was seen between the presence of erosion and the consumption of any other drinks at 15-months ($p \geq 0.056$), although the consumption of cola just failed to reach significance ($p=0.056$).

At 24-months, a statistically significant association was demonstrated between the consumption of other carbonated drinks and the presence of erosion ($p=0.029$, Table 7.7). The consumption of other fruit drinks just failed to reach significance ($p=0.055$). No associations were evident between the frequency of consumption of the remaining drinks and the presence of erosion at 24-months ($p \geq 0.222$).

The total weekly consumption of carbonated drinks at 24-months produced a statistically significant association with the presence of erosion ($p=0.033$), with markedly different intakes. Although the median consumption was the same for the children with and without erosion (1.0), there were approximately half the number of children in the erosion group and therefore this would imply that these children had more frequent intakes of cola. The mean consumption of those with erosion was 2.7 (SD 4.8) and of those without erosion was 1.7 (SD 2.8). No significant association was demonstrated between the total consumption of non-carbonated drinks or both carbonated and non-carbonated drinks at 24-months ($p \geq 0.063$) and the presence of erosion, although the median values were between 18 and 20 for the children in each group.

7.2.3.2 Palatal erosion

No significant association was demonstrated between the consumption of any drinks at 6-months and the presence of palatal erosion ($p \geq 0.107$, Table 7.8).

A strong association was demonstrated between palatal erosion and the consumption of fruit drinks at 15-months ($p=0.004$, Table 7.9). The children with erosion had a median consumption of 4.0 whilst the median was 2.0 in the children without erosion. There was no association between the frequency of consumption of the remaining drinks at 15-months and the presence of palatal erosion ($p \geq 0.062$).

At 24-months, the consumption of other carbonated drinks was significantly associated with the presence of palatal erosion ($p=0.03$, Table 7.10). However, there was no significant association between the consumption of any other drinks at 24-months in the children with or without palatal erosion ($p \geq 0.071$). When the weekly consumption of all carbonated drinks at 24-months was compared with the presence of palatal erosion there was a significant association between the consumption of the children with and without erosion ($p=0.026$). However, the total consumption of non-carbonated drinks and both carbonated and non-carbonated drinks at 24-months were not significantly associated with palatal erosion ($p \geq 0.067$).

7.2.3.3 Labial erosion

Only 1% of children were consuming cola or other carbonated drinks at 6-months. However, an association was demonstrated between the consumption of these drinks and the presence of labial erosion ($p \leq 0.029$, Table 7.11). Closer inspection of these cases showed that only one child who had been given cola or other carbonated drinks at 6-months showed evidence of labial erosion at 61-months. No significant association was demonstrated between the consumption of the remaining drinks at 6- and 15-months ($p \geq 0.057$, Table 7.12). A significant association was evident between consumption of cola at 24-months and the presence of labial erosion ($p=0.046$, Table 7.13). However, no other significant associations were demonstrated ($p \geq 0.068$).

7.2.3.4 Molar erosion

Only 2% of children had erosion on the occlusal surfaces of the lower first molar teeth. There was no association between the frequency of consumption of any drinks at any age ($p \geq 0.120$, Tables 7.14, 7.15 and 7.16) or the total consumption of the carbonated and/or non- carbonated drinks ($p \geq 0.101$) and the presence of erosion on the molar teeth.

7.2.4 Socio-demographic influence on prevalence of dental erosion

Socio-demographic factors were compared with the prevalence of erosion in the group using the Chi-squared distribution test (χ^2). The mothers' home ownership status, educational level and age at delivery were used as previously described (Sections 5.2.1, 5.2.2 and 5.2.3). **The null hypothesis (4) tested was that socio-demographic factors are not associated with the presence of erosion in the primary dentition of this study group.**

Significant association was evident between the presence of any erosion or palatal erosion and home ownership status ($p \leq 0.005$, Table 7.17). Although fewer children were living in council or rented accommodation (17%), those who did were more likely to have erosion (45.3%) than those living in owned or mortgaged accommodation (32.3%). No associations were present between labial and molar erosion and home ownership ($p \geq 0.908$) and this was, in part, due to the very small number of children within these erosion groups.

No associations were demonstrated between erosion at any site and the educational level of the mother ($p \geq 0.357$, Table 7.18) and no trends were noted.

An association was apparent between maternal age and the presence of any erosion and palatal erosion ($p \leq 0.038$, Table 7.19). Almost 53% of the children were born to younger mothers and of these 38% had evidence of erosion compared with 31% of children with older mothers. A similar trend was associated with palatal erosion. Associations were not evident between maternal age and the small number of children with labial or molar erosion ($p \geq 0.941$) and no clear trends were noted.

7.3 Summary of the influence of drinking habits and socio-demographic factors on dental erosion

In this study group, 94% (813 children) had consumed carbonated or non-carbonated drinks by 24-months. The proportion of children (1%) consuming carbonated drinks at 6-months was small. This had increased to 47% by 24-months, although the median of the total consumption of all carbonated drinks remained low (Table 7.7), particularly when compared with that of the non-carbonated drinks. The frequency of consumption of non-carbonated drinks was considerably higher than the carbonated drinks at each time point.

The palatal incisor surface was affected by erosion in a greater number of children than the labial incisor surface and the occlusal surface of the molar teeth.

The null hypothesis (3) is rejected. In this study group, who were examined at 61-months of age, the frequency of consumption of carbonated and non-carbonated drinks at 15- and 24-months was associated with the presence of palatal incisor erosion. Total consumption of all carbonated drinks showed significant association with palatal erosion (p=0.026) and any evidence of erosion in the children's dentition (p=0.033).

The null hypothesis (4) is rejected. Home ownership status and maternal age were associated with the presence of palatal erosion. A greater proportion of the children with palatal erosion had younger mothers and lived in council or rented accommodation.

Table 7.1: Number (%) of children with erosion

Erosion	n	%	Valid %
Erosion of 1 or more surfaces	270	100.0	100.0
Palatal erosion:			
No erosion	5	1.9	1.9
Erosion	264	97.8	98.1
Missing cases	1	0.4	
Total	270		
Labial erosion:			
No erosion	225	83.3	87.9
Erosion	31	11.5	12.1
Missing cases	14	5.2	
Total	270		
Molar erosion:			
No erosion	217	80.4	92.7
Erosion	17	6.3	7.3
Missing cases	36	13.3	
Total	270		

Table 7.2: Proportion of children who consumed each drink at 6-, 15- and 24-months

Drink	6-months	15-months	24-months
Cola	1%	19%	45%
Other carbonated drinks	1%	20%	50%
Apple juice	22%	46%	45%
Blackcurrant or rosehip drink	32%	54%	47%
Other fruit juice	N/A	66%	66%
Other fruit drink	53%	65%	77%

N/A Not asked at 6-months

Table 7.3: Proportion of the 867 children consuming specified drinks at 6- and 15-months (χ^2 test for trend)

Drinks at 15-months	n	Number of children drinking				χ^2	p value
		Yes/n @ 6-months		Yes/n @ 15-months			
Cola	816	7	1%	167	20%	18	<0.0001^{+}
Other carbonated drinks	813	6	1%	175	21%	3	0.118^{+NS}
Apple juice	814	184	23%	394	48%	79	<0.0001
Blackcurrant or rosehip drink	813	266	33%	469	58%	38	<0.0001
Other fruit drink at 6-m BY Other fruit juice at 15-m	805	440	55%	568	71%	18	<0.0001
Other fruit drink	807	440	54%	560	70%	5	0.024*

^{NS} p>0.05   * p<0.05 $^{+}$ Fisher's exact test

Table 7.4: Proportion of the 867 children consuming specified drinks at 15- and 24-months (χ^2 test for trend)

Drink type	n	Number of children drinking				χ^2	p value
		Yes/n @ 15-months		Yes/n @ 24-months			
Cola	805	160	20%	141	47%	135	<0.0001
Other carbonated drinks	799	170	21%	421	53%	89	<0.0001
Apple juice	801	388	48%	358	45%	162	<0.0001
Blackcurrant or rosehip drink	799	458	57%	392	49%	79	<0.0001
Other fruit juice	782	558	71%	547	70%	68	<0.0001
Other fruit drink	797	556	70%	644	81%	128	<0.0001

Table 7.5: Frequency of intake of specified drinks (per week) at 6-months compared with the presence of any erosion at the 61-month clinic

Drink at 6-m	Any erosion	n	Median	U	p
Cola	No	500	0.0	65764	0.515 NS
	Yes	264	0.0		
Other carbonated drinks	No	501	0.0	65895	0.514 NS
	Yes	264	0.0		
Apple juice	No	493	0.0	63032	0.666 NS
	Yes	259	0.0		
Blackcurrant or rosehip drink	No	490	0.0	59583	0.154 NS
	Yes	256	0.0		
Other fruit drink	No	487	0.0	59563	0.366 NS
	Yes	254	0.0		

NS $p>0.05$ U Mann-Whitney test

Table 7.6: Frequency of intake of specified drinks (per week) at 15-months compared with the presence of any erosion at the 61-month clinic

Drink at 15-m	Any erosion	n	Median	U	p
Cola	No	478	0.0	56285	0.056 NS
	Yes	247	0.0		
Other carbonated drinks	No	478	0.0	58353	0.557 NS
	Yes	248	0.0		
Apple juice	No	469	0.0	56747	0.533 NS
	Yes	248	0.0		
Blackcurrant or rosehip drink	No	461	0.0	55555	0.846 NS
	Yes	243	0.0		
Other fruit juice	No	461	1.0	54202	0.861 NS
	Yes	237	2.0		
Other fruit drink	No	459	2.0	48461	0.002**
	Yes	244	4.0		

NS $p>0.05$ ** $p<0.01$ U Mann-Whitney test

Table 7.7: Frequency of intake of specified drinks (per week) at 24-months compared with the presence of any erosion at the 61-month clinic

Drink at 24-m	Any erosion	n	Median	U	p
Cola	No Yes	475 241	0.0 0.0	54525	0.222 NS
Other carbonated drinks	No Yes	473 236	0.0 0.0	50776	0.029*
Apple juice	No Yes	470 244	0.0 0.0	56624	0.746 NS
Blackcurrant or rosehip drink	No Yes	474 239	0.0 0.0	56539	0.965 NS
Other fruit juice	No Yes	459 232	2.0 2.0	51732	0.532 NS
Other fruit drink	No Yes	474 233	6.0 7.0	50367	0.055 NS
ALL carbonated drinks	No Yes	467 233	1.0 1.0	49329	0.033*
ALL non-carbonated drinks	No Yes	443 215	18.0 19.0	43738	0.089 NS
ALL drinks	No Yes	432 208	19.0 20.0	40857	0.063 NS

NS $p>0.05$ * $p<0.05$ ** $p<0.01$ U Mann-Whitney test

Table 7.8: Frequency of intake of specified drinks (per week) at 6-months compared with the presence of palatal incisor erosion at the 61-month clinic

Drink at 6-m	Palatal incisor erosion	n	Median	U	p
Cola	No	547	0.0	70274	0.441 NS
	Yes	258	0.0		
Other carbonated drinks	No	548	0.0	70402	0.440 NS
	Yes	258	0.0		
Apple juice	No	537	0.0	67053	0.475 NS
	Yes	255	0.0		
Blackcurrant or rosehip drink	No	533	0.0	62907	0.107 NS
	Yes	250	0.0		
Other fruit drink	No	531	0.0	63425	0.317 NS
	Yes	249	0.0		

NS $p>0.05$ U Mann-Whitney test

Table 7.9: Frequency of intake of specified drinks (per week) at 15-months compared with the presence of palatal incisor erosion at the 61-month clinic

Drink at 15-m	Palatal incisor erosion	n	Median	U	p
Cola	No	521	0.0	60165	0.062 NS
	Yes	242	0.0		
Other carbonated drinks	No	521	0.0	62655	0.694 NS
	Yes	243	0.0		
Apple juice	No	509	0.0	60134	0.472 NS
	Yes	243	0.0		
Blackcurrant or rosehip drink	No	503	0.0	58954	0.717 NS
	Yes	238	0.0		
Other fruit juice	No	500	1.0	57733	0.917 NS
	Yes	232	2.0		
Other fruit drink	No	502	2.0	52287	0.004**
	Yes	239	4.0		

NS $p>0.05$ ** $p<0.01$ U Mann-Whitney test

Table 7.10: Frequency of intake of specified drinks (per week) at 24-months compared with the presence of palatal incisor erosion at the 61-month clinic

Drink at 24-m	Palatal incisor erosion	n	Median	U	p
Cola	No Yes	516 235	0.0 0.0	57232	0.147 NS
Other carbonated drinks	No Yes	515 230	0.0 0.0	53939	0.030*
Apple juice	No Yes	511 238	0.0 0.0	59726	0.639 NS
Blackcurrant or rosehip drink	No Yes	513 233	0.0 0.0	59700	0.979 NS
Other fruit juice	No Yes	498 226	2.0 2.0	53811	0.334 NS
Other fruit drink	No Yes	513 228	7.0 7.0	53683	0.071 NS
ALL carbonated drinks	No Yes	508 227	1.0 1.0	52057	0.026*
ALL non-carbonated drinks	No Yes	479 210	18.0 19.0	46269	0.094 NS
ALL drinks	No Yes	467 203	19.0 20.0	43179	0.067 NS

NS $p>0.05$ * $p<0.05$ ** $p<0.01$ U Mann-Whitney test

Table 7.11: Frequency of intake of specified drinks (per week) at 6-months compared with the presence of labial incisor erosion at the 61-month clinic

Drink at 6-m	Labial incisor erosion	n	Median	U	p
Cola	No	767	0.0	11551	0.029*
	Yes	31	0.0		
Other carbonated drinks	No	768	0.0	11566	0.028*
	Yes	31	0.0		
Apple juice	No	755	0.0	11421	0.730 NS
	Yes	31	0.0		
Blackcurrant or rosehip drink	No	746	0.0	9733	0.057 NS
	Yes	31	0.0		
Other fruit drink	No	746	0.0	10437	0.494 NS
	Yes	30	0.0		

NS $p>0.05$ * $p<0.05$ U Mann-Whitney test

Table 7.12: Frequency of intake of specified drinks (per week) at 15-months compared with the presence of labial incisor erosion at the 61-month clinic

Drink at 15-m	Labial incisor erosion	n	Median	U	p
Cola	No	728	0.0	10474	0.896 NS
	Yes	29	0.0		
Other carbonated drinks	No	728	0.0	10313	0.714 NS
	Yes	29	0.0		
Apple juice	No	718	0.0	8507	0.106 NS
	Yes	28	0.0		
Blackcurrant or rosehip drink	No	709	0.0	8402	0.133 NS
	Yes	28	1.5		
Other fruit juice	No	700	2.0	9840	0.773 NS
	Yes	29	2.0		
Other fruit drink	No	705	2.0	8549	0.123 NS
	Yes	29	5.0		

NS $p>0.05$ U Mann-Whitney test

Table 7.13: Frequency of intake of specified drinks (per week) at 24-months compared with the presence of labial incisor erosion at the 61-month clinic

Drink at 24-m	Labial incisor erosion	n	Median	U	p
Cola	No Yes	718 28	0.0 0.5	8161	0.046*
Other carbonated drinks	No Yes	712 28	0.0 0.0	9035	0.348 NS
Apple juice	No Yes	715 29	0.0 0.0	9190	0.216 NS
Blackcurrant or rosehip drink	No Yes	714 28	0.0 0.0	9624	0.712 NS
Other fruit juice	No Yes	694 26	2.0 1.5	8234	0.439 NS
Other fruit drink	No Yes	710 27	7.0 7.0	7623	0.068 NS
ALL carbonated drinks	No Yes	703 27	1.0 1.0	8162	0.191 NS
ALL non-carbonated drinks	No Yes	662 23	18.0 21.0	6756	0.358 NS
ALL drinks	No Yes	645 21	20.0 22.0	6036	0.396 NS

NS $p>0.05$ * $p<0.05$ U Mann-Whitney test

Table 7.14: Frequency of intake of specified drinks (per week) at 6-months compared with the presence of molar incisor erosion at the 61-month clinic

Drink at 6-m	Molar incisor erosion	n	Median	U	p
Cola	No Yes	737 17	0.0 0.0	6230	0.761 ^{NS}
Other carbonated drinks	No Yes	738 17	0.0 0.0	6230	0.734 ^{NS}
Apple juice	No Yes	728 15	0.0 0.0	4853	0.268 ^{NS}
Blackcurrant or rosehip drink	No Yes	721 17	0.0 0.0	5957	0.803 ^{NS}
Other fruit drink	No Yes	718 15	0.0 3.0	4487	0.229 ^{NS}

^{NS} p>0.05 U Mann-Whitney test

Table 7.15: Frequency of intake of specified drinks (per week) at 15-months compared with the presence of molar incisor erosion at the 61-month clinic

Drink at 15-m	Molar incisor erosion	n	Median	U	p
Cola	No Yes	698 16	0.0 0.0	5476	0.809 ^{NS}
Other carbonated drinks	No Yes	700 16	0.0 0.0	4862	0.120 ^{NS}
Apple juice	No Yes	691 16	0.0 0.0	5225	0.661 ^{NS}
Blackcurrant or rosehip drink	No Yes	680 16	0.0 2.0	4740	0.334 ^{NS}
Other fruit juice	No Yes	674 16	1.0 2.0	5291	0.895 ^{NS}
Other fruit drink	No Yes	677 16	2.0 7.0	4592	0.283 ^{NS}

^{NS} p>0.05 U Mann-Whitney test

Table 7.16: Frequency of intake of specified drinks (per week) at 24-months compared with the presence of molar incisor erosion at the 61-month clinic

Drink at 24-m	Molar incisor erosion	n	Median	U	p
Cola	No Yes	691 17	0.0 0.0	5300	0.418 ^{NS}
Other carbonated drinks	No Yes	685 17	0.0 0.0	4949	0.238 ^{NS}
Apple juice	No Yes	688 17	0.0 0.0	5835	0.985 ^{NS}
Blackcurrant or rosehip drink	No Yes	691 16	0.0 0.0	4798	0.314 ^{NS}
Other fruit juice	No Yes	668 17	2.0 5.0	4794	0.262 ^{NS}
Other fruit drink	No Yes	681 16	7.0 7.0	4223	0.120 ^{NS}
ALL carbonated drinks	No Yes	676 17	1.0 1.0	4849	0.246 ^{NS}
ALL non-carbonated drinks	No Yes	635 15	18.0 21.0	3863	0.211 ^{NS}
ALL drinks	No Yes	617 15	20.0 24.0	3482	0.101 ^{NS}

^{NS} p>0.05 U Mann-Whitney test

Table 7.17: Proportion of children within each home ownership group by proportion of children with erosion at 61-months

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
Any erosion	n=772 100.0%	644	83.4%	128	16.6%	8	0.005**
	Yes 266 (34.5%)	208	32.3%	58	45.3%		
	No 506 (65.5%)	436	67.7%	70	54.7%		
Palatal erosion	n=812 100.0%	673	82.9%	139	17.1%	7	0.007**
	Yes 260 (32.0%)	202	30.0%	58	41.7%		
	No 552 (68.0%)	471	70.0%	81	58.3%		
Labial erosion	n=805 100.0%	669	83.1%	136	16.9%	0.01	0.908^{NS}
	Yes 31 (3.9%)	26	3.9%	5	3.7%		
	No 774 (96.1%)	643	96.1%	131	96.3%		
Molar erosion	n=761 100.0%	644	84.6%	117	15.4%	0.2	1.00$^{+ NS}$
	Yes 17 (2.2%)	15	2.3%	2	1.7%		
	No 744 (97.8%)	629	97.7%	115	98.3%		

^{NS} p>0.05 ** p<0.01 $^{+}$Fisher's exact test

Table 7.18: Proportion of children within each maternal education group by proportion of children with erosion at 61-months

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
Any erosion	n=765 100.0%	423	55.3%	342	44.7%	0.8	0.357[NS]
	Yes 264 (34.5%)	152	35.9%	112	32.7%		
	No 501 (65.5%)	271	64.1%	230	67.3%		
Palatal erosion	n=807 100.0%	455	56.4%	352	43.6%	0.3	0.591[NS]
	Yes 258 (32.0%)	149	32.7%	109	31.0%		
	No 549 (68.0%)	306	67.3%	243	69.0%		
Labial erosion	n=800 100.0%	449	56.1%	351	43.9%	0.004	0.951[NS]
	Yes 30 (3.8%)	17	3.8%	13	3.7%		
	No 770 (96.3%)	432	96.2%	338	96.3%		
Molar erosion	n=755 100.0%	419	55.5%	336	44.5%	0.08	0.780[NS]
	Yes 17 (2.3%)	10	2.4%	7	2.1%		
	No 738 (97.7%)	409	97.6%	329	97.9%		

[NS] $p>0.05$

Table 7.19: Proportion of children within each maternal age group by proportion of children with erosion at 61-months

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	p value
Any erosion	n=783 100.0%	414	52.9%	369	47.1%	4	0.038*
	Yes 269 (34.4%)	156	37.7%	113	30.6%		
	No 514 (65.6%)	258	62.3%	256	69.4%		
Palatal erosion	n=825 100.0%	434	52.6%	391	47.4%	5	0.028*
	Yes 263 (31.9%)	153	35.3%	110	28.1%		
	No 562 (68.1%)	281	64.7%	281	71.9%		
Labial erosion	n=817 100.0%	427	52.3%	390	47.7%	0.005	0.941^{NS}
	Yes 31 (3.8%)	16	3.7%	15	3.8%		
	No 786 (96.2%)	411	96.3%	375	96.2%		
Molar erosion	n=773 100.0%	412	53.3%	361	46.7%	0.001	0.976^{NS}
	Yes 17 (2.2%)	9	2.2%	8	2.2%		
	No 756 (97.8%)	403	97.8%	353	97.8%		

^{NS} $p>0.05$ * $p<0.05$

CHAPTER 8

THE INFLUENCE OF NON-NUTRITIVE SUCKING HABITS ON THE DEVELOPING DENTITION

8.1 Introduction

The development of occlusion combines the effects of growth, tooth eruption and the influence of orofacial musculature. Normal occlusion has been described in the literature (Clinch 1951, Friel 1954), although some question its existence (Day and Foster 1971, Leighton 1971). However, it serves as a baseline against which the extent and importance of deviations from the norm can be assessed.

The effects of non-nutritive sucking habits on the harmony of occlusal development are well documented (Johnson and Larson 1993, Moore 1996). Whilst longitudinal data is available in other countries such as Sweden and USA, few studies of sucking habits in preschool children have been carried out in the United Kingdom. Digit and dummy sucking habits influence the alignment of the labial segments and anterior and posterior occlusion in the developing dentition (Bowden 1966, Svedmyr 1979, Johnson and Larson 1993).

This study recorded longitudinal information regarding the dentition of the Children in Focus at 31-, 43- and 61- months of age. It considered the alignment of the labial segments and occlusion of the children at the three ages. The parents provided information about digit and dummy sucking habits of the children at 15-, 24- and 36-months of age. These data were used to determine the influence of sucking habits on the developing dentition of the children.

The null hypothesis (5) tested was that non-nutritive sucking habits are not associated with disturbances in the developing occlusion in this group of children.

8.2 Results

8.2.1 Arch form

The data reporting the alignment of the labial segments at 31-, 43- and 61-months are in Table 8.1. These data were modified (Section 2.8.2) for purposes of analysis.

8.2.1.1 Comparison between the labial segment alignment at 31-, 43- and 61-months

The Chi-squared test (χ^2) for trend (Section 2.10.2) was used to illustrate changes in the alignment of the upper and lower labial segments as the child got older. In each case there was a significant increase in the proportion of children with spaced labial segments.

Complete data for the upper labial segment alignment at 31-, 43- and 61-months were available for 797 children. At 31-months, 39% of children had a spaced upper labial segment increasing to 45% at 43-months and 47.8% at 61-months ($p<0.0001$, Tables 8.2, 8.3 and 8.4). Data for the lower labial segment alignment was available for 799 children. Spacing in the lower arch increased significantly with time ($p<0.0001$, Tables 8.5, 8.6 and 8.7) with 41.2% spaced at 31-months, 49.9% at 43-months and 55.2% at 61-months. At 31-months 27.7%

of the children were spaced in both arches and this similarly increased to 33.3% at 43-months and 38.4% at 61-months ($p<0.0001$, Tables 8.8, 8.9 and 8.10).

8.2.2 Occlusion

8.2.2.1 Anterior occlusion

The proportion of children with an affected anterior occlusion (open bite) and reverse overjet (Section 2.5.3.1) is given in Table 8.1. The open bite data were modified (Section 2.8.3) and these were used for the analyses.

Data for open bite and overjet were available for 799 children at 31-, 43- and 61-months. The open bite had a tendency to close with time (Tables 8.11, 8.12 and 8.13). At 31-months, 21.5% of children had an open bite decreasing to 19.3% at 43-months and to 10.5% at 61-months. Only 26.8% of those who had an open bite at 31-months still had an open bite at 61-months. The proportion of children with a reverse overjet was small. Very little change was seen between the proportion of cases with a reverse overjet at each clinic (Tables 8.14, 8.15 and 8.16). At 31-months, 1.4% of the children were reported to have a reverse overjet. This slightly increased to 2.1% at 43-months and decreased to 1.8% at 61-months. Of 11 children with a reverse overjet at 31-months, nine still presented at 43-months and seven at 61-months ($p<0.0001$).

8.2.2.2 Posterior occlusion

The posterior occlusion was recorded (Section 2.5.3.2) and the distribution of the unilateral and bilateral crossbites is given in Table 8.1. A more detailed breakdown of the distribution of the anterior and posterior occlusions is in

Appendix 8.1. The data were modified (Section 2.8.4) and analysis was carried out using these figures.

There was a highly significant association between posterior crossbite at 31-, 43- and 61-months ($p<0.0001$, Tables 8.17, 8.18 and 8.19). The proportion of children with posterior crossbite was markedly similar at all three clinics (12%). When the anterior and posterior occlusions were compared, 8.6% of children had both open bite and posterior crossbite at 31-months and this decreased to 5% at 43-months and to 3% at 61-months ($p<0.0001$, Tables 8.20, 8.21 and 8.22).

8.2.3 Summary of arch form and occlusion

In this study group, the upper and lower labial segments became more spaced with an increase in age from 31- to 43-months and 43- to 61-months. An open bite at 31-months of age had a tendency to close by 61-months ($p<0.0001$), although little change was observed in the presence of a reverse overjet. Very little change was seen in the posterior occlusion from 31- to 61-months of age.

A record of anterior occlusion at 31-, 43- and 61-months and the presence or absence of a posterior crossbite prior to modification (Section 2.8.4) is in Appendix 8.1.

8.2.4 Non-nutritive sucking habits

The sucking habits of the children were reported at 15-, 24- and 36-months. The data were modified (Section 2.8.6) and these are presented in Table 8.23. The information had not been supplied for all children and so at each time-point only those children for whom data were held were compared and this accounts for the difference in the number of cases analysed at each time-point. Table 8.23 clearly shows that the dummy habit declined significantly between 24- and 36-months of age, whereas the digit habit, although not used by as many children, continued at a similar level throughout these early years. By 36-months, 73.4% of the children were reported to suck neither dummies nor digits.

The digit and dummy sucking habits were compared with the developing occlusion at 31-, 43- and 61-months of age. Many combinations of the sucking habits could be derived. However, the effects of the known habits at each time-point (15-, 24- and 36-months) are reported and also those produced by persistent sucking habits. Persistent suckers were defined as those children who sucked at two or more of the three time-points.

A tabulated summary of the following results reporting the influence of non-nutritive sucking habits on occlusal features is in Appendix 8.2.

8.2.4.1 Digit sucking habit at 15-months of age and their effect on occlusal development

Around 23% of the children sucked a thumb or finger at 15-months (Table 8.24). There was a significant association between the alignment of the upper labial segment at 43- and 61-months in those children with a digit sucking habit at 15-months of age ($p \leq 0.035$, Table 8.24), but no association at 31-months ($p=0.288$). However, in each case, those children who had a sucking habit were more likely to have a spaced upper segment than those who did not.

There was no association between the proportion of children with spaced lower labial segments at any age and the sucking habit at 15-months ($p \geq 0.301$, Table 8.25).

Although no associations existed between the children with a digit habit at 15-months and the presence of an open bite at 31- and 43-months ($p \geq 0.055$, Table 8.26), 23.8% of those who sucked had an open bite at 43-months, compared with 17.4% of those who had not. There was an association between those children who had sucked and the presence of an open bite at 61-months ($p<0.0001$); 19.4% of digit suckers had an open bite compared with only 7.6% of non-suckers.

There was no significant association between the presence of posterior crossbite at any age and a digit habit at 15-months ($p \geq 0.118$, Table 8.27).

8.2.4.2 Digit sucking habits at 24-months of age and their effect on occlusal development

Around 21% of the children had a digit sucking habit at 24-months of age (Table 8.28).

There was a significant association between the alignment of the upper labial segment alignment at all ages and a digit habit at 24-months ($p \leq 0.036$, Table 8.28). Those who had sucked had a greater tendency toward a spaced upper labial segment.

No association could be demonstrated between digit sucking at 24-months and the alignment of the lower labial segment ($p \geq 0.424$, Table 8.29) at any age.

There was no association between the children with open bite at 31-months and digit sucking at 24-months ($p=0.559$, Table 8.30). However associations were seen at 43- and 61-months ($p \leq 0.002$) and 25% of those who sucked had an open bite at 43-months compared with 14% of those who did not suck. At 61-months, 21% of digit suckers had an open bite compared with 6% of those with no digit habit.

There was no association between the children who did and did not suck a digit at 24-months and presence of posterior crossbite at any age ($p \geq 0.066$, Table 8.31).

8.2.4.3 Digit sucking habits at 36-months of age and their effect on occlusal development

Approximately 19% of the children were reported to suck a thumb or finger at 36-months of age (Table 8.32). The digit habit was compared with the occlusal features for the 43- and 61-month clinics.

An association was seen between the alignment of the upper labial segment at 43-months and the digit habit at 36-months ($p=0.022$, Table 8.32). However, there was no association between the sucking habit and alignment of the upper segment at 61-months ($p=0.363$). In each case, a greater proportion of the children who sucked had a spaced labial segment than those who did not, although the majority of the children who were spaced were not digit suckers.

No association could be demonstrated between digit sucking at 36-months and the alignment of the lower labial segment at either age ($p \geq 0.918$, Table 8.33).

A strong association was demonstrated between a history of digit sucking at 36-months and an open bite at 43- and 61-months ($p<0.0001$, Table 8.34). Of those with a sucking habit, 28% had an open bite at 43-months compared with 14% of those without the habit. At 61-months, 23% of suckers had an open bite compared with 6.5% of non-suckers.

A significant association was demonstrated between digit sucking at 36-months and the proportion of children with posterior crossbite at both ages ($p \leq 0.029$, Table 8.35). At 43-months, 17% of suckers had posterior crossbite compared with 10% of non-suckers and at 61-months, 19% of suckers had a crossbite compared with 10% of those who did not.

8.2.4.4 Persistent digit sucking habits

Around 15% of the children sucked a digit at two or more time-points, that is at 15- and 24-, 24- and 36-, 15 and 36-months or 15-, 24 and 36-months (Table 8.36). The occlusal features of those children at 43- and 61-months were compared with the sucking habit using the Chi-squared test (χ^2) for trend.

At both 43- and 61-months, around 59% of persistent suckers, had spaced upper labial segments ($p \leq 0.013$, Table 8.36) compared with around 45% of inconsistent suckers. There was very little difference in the proportion of children with lower labial spacing in either sucking group ($p \geq 0.204$, Table 8.37). Although associations were seen between the proportion of persistent suckers with an open bite at 43- and 61-months ($p \leq 0.029$, Table 8.38), the majority of open bite was seen in children who did not have a persistent digit habit. However, a greater proportion of those who were persistent suckers had open bite than those who were not. When posterior crossbite was compared with the persistent sucking habit, an association was demonstrated at 61-months ($p=0.044$, Table 8.39) but not at 43-months ($p=0.347$). However, in both cases the majority of children with the sucking habit had a normal posterior crossbite, although within the persistent sucking group, a larger proportion had crossbite than those who were inconsistent suckers.

8.2.4.5 Dummy sucking habits at 15-months of age and their effect on occlusal development

In all, 38% of the children sucked a dummy at 15-months of age (Table 8.40).

In this study group, a dummy sucking habit at 15-months was shown to be associated with a spaced upper labial segment at 61-months ($p<0.0001$, Table 8.40) and 37.7% of dummy suckers had a spaced upper arch. No other associations were apparent ($p\geq0.06$). A strong association was demonstrated between the lower labial segment alignment at 31-months and the sucking habit at 15-months ($p<0.0001$, Table 8.41). In this case, 48.8% of those who sucked had spaced arches compared with 35.6% of those who did not suck. There were no associations at the 43- and 61-month clinics ($p\geq0.271$).

There was a strong association between dummy sucking at 15-months and open bite at 31-, 43 and 61-months ($p\leq0.003$, Table 8.42). In each case, a higher proportion of those children with an open bite were in the dummy sucking group, although fewer of this group had an open bite at 61-months (14.5%) than at 31-months (45%) or 43-months (37%). There was a significant association between the proportion of children with posterior crossbite within the two sucking groups ($p<0.0001$, Table 8.43). In each case the children who sucked a dummy at 15-months had a greater tendency to have crossbite than those who did not suck.

8.2.4.6 Dummy sucking habits at 24-months of age and their effect on occlusal development

Approximately 35% of the study group sucked a dummy at 24-months of age (Table 8.44).

A history of dummy sucking at 24-months was associated with the alignment of the upper labial segment at 43- and 61-months ($p \leq 0.012$, Table 8.44). In both cases the upper labial segment was less likely to be spaced in those who sucked than those who did not.

Dummy sucking at 24-months was strongly associated with the lower labial segment alignment at 31-months ($p < 0.0001$, Table 8.45) and those who sucked were more likely to have a spaced lower labial segment than those who did not. No association was demonstrated between the habit and the upper labial segment alignment at 31-months or the lower labial segment alignment at 43- or 61-months ($p \geq 0.340$).

Highly significant associations were demonstrated between a dummy sucking habit at 24-months and presence of open bite and posterior crossbite at all ages ($p < 0.0001$, Tables 8.46 and 8.47). In each case, those who sucked a dummy were more likely to have affected occlusions.

8.2.4.7 Dummy sucking habits at 36-months of age and their effect on occlusal development

Around 18% of the children were dummy suckers at 36-months (Table 8.48).

A highly significant association was found between a dummy sucking habit at 36-months and the upper labial segment alignment at 61-months ($p < 0.0001$, Table 8.48) and those who sucked were less likely to have spacing in the upper segment. A strong association was found between dummy sucking at 36-months and the lower labial segment alignment at 43-months ($p < 0.001$, Table 8.49). A greater proportion of those who sucked had spaced lower labial segments than those who did not. Although no association was seen with the lower segment at 61-months ($p=0.907$), there was still a tendency for more children to be spaced if they had a history of sucking at 36-months.

Highly significant association was found between dummy sucking at 36-months and open bite and posterior crossbite at 43- and 61-months ($p<0.0001$, Tables 8.50 and 8.51). In all cases, those who sucked a dummy at 36-months were more likely to have an open bite or posterior crossbite than those who did not suck at 36-months.

Interestingly, 74% of dummy suckers at 43-months had an affected anterior occlusion compared with 27% at 61-months.

8.2.4.8 Persistent dummy sucking habits and their effect on occlusal development

Around 34% of children sucked a dummy at two or more time-points, that is 15- and 24-, 24- and 36-, 15 and 36-months or 15-, 24 and 36-months (Table 8.52). The occlusal features of those children at 43- and 61-months were compared with the sucking habit using Chi-squared test (χ^2) for trend.

A significant association was found between a persistent dummy sucking habit and the upper labial segment alignment at both 43- and 61-months ($p\leq0.032$, Table 8.52), although in each case the trend was for the majority of children with spacing to fall within the group who were infrequent suckers.

There were no associations between the lower labial segment and a persistent dummy habit ($p\geq0.263$, Table 8.53).

There was a strong association between the persistent dummy habit and open bite at 43- and 61-months ($p<0.0001$, Table 8.54). In both cases more children with open bite fell into the persistent sucking group. At 43-months, 51.6% of persistent suckers had open bite compared with only 4.5% of inconsistent suckers and at 61-months, 16.9% of persistent suckers had open bite compared with 5.6% of inconsistent suckers.

Similarly, posterior crossbite was strongly associated with the persistent dummy habit at both 43- and 61-months ($p<0.0001$, Table 8.55) with 23% of persistent suckers having posterior crossbite compared with only 6% of inconsistent suckers at both ages.

8.2.5 Socio-demographic influence on prevalence *of non-nutritive sucking* habits

Socio-demographic factors were compared with persistent sucking habits of the children using the Chi-squared distribution test (χ^2). The mothers' home ownership status, educational level and age at delivery were used as previously described (Sections 5.2.1, 5.2.2 and 5.2.3).

The null hypothesis (6) tested was that home ownership status, maternal education and age at delivery are not associated with non-nutritive sucking habits in these children.

There were no significant associations between the mothers' home ownership status, educational level or age at delivery and the proportion of children with a persistent digit habit ($p\geq0.213$, Tables 8.56, 8.57 and 8.58). However, the null hypothesis (6) is rejected, since there were significant associations between the maternal educational level and age at delivery and the proportion of children with a persistent dummy habit ($p=0.001$). A greater proportion of children with younger, lower educated mothers had a persistent dummy habit (40%) than children with older, higher educated mothers (28%).

8.3 Summary of the influence of non-nutritive sucking habits on the developing dentition

The null hypothesis (5) is rejected. Digit sucking habits were associated with variations in the dental development of the children examined at the 31-, 43- and 61-month clinics and in particular with the upper labial segment at 43-months ($p \le 0.035$) and anterior occlusion at 61-months ($p < 0.0001$). However, it was the persistent digit habit and digit sucking at 36-months that had the strongest associations with the posterior occlusion at 43- and 61-months ($p \le 0.044$). In these cases, the digit habit was associated with spaced upper labial segments, open bite and posterior crossbite. No associations were found between the digit habit and the lower labial segment alignment at any age ($p \ge 0.301$).

Dummy sucking habits had the most profound influence on the anterior and posterior occlusion of the children at all ages. Whether the habit was considered at each time-point or as a confirmed persistent habit, it was strongly associated with the presence of an open bite and posterior crossbite ($p < 0.0001$) at 31-, 43- and 61-months. The persistent dummy habit and dummy sucking at 24-months were associated with no spacing in upper labial segments at 43- and 61-months ($p \le 0.032$). However, a higher proportion of children with a dummy habit at 24-months had spacing in the lower labial segment at 43-months than those children who did not suck at that time. Persistent digit and dummy sucking habits were associated with effects on the alignment of the upper labial segment and the anterior and posterior occlusion at 61-months.

Table 8.1: Record of arch form and occlusion for each clinic

	31-months		43-months		61-months	
	n	%	n	%	n	%
Upper labial segment (U)						
Well-aligned	549	65.4	501	59.2	421	49.9
Crowded	29	3.5	57	6.7	43	5.1
Spaced	261	31.1	288	34.0	379	45.0
Upper median diastema	141	16.8	170	20.0	116	13.5
Lower labial segment (L)						
Well-aligned	424	50.9	369	43.6	291	34.2
Crowded	77	9.2	87	10.3	110	12.9
Spaced	332	39.9	391	46.2	449	52.8
Lower median diastema	28	3.4	43	5.1	47	5.5
Anterior open bite						
Symmetrical	128	15.7	141	16.8	87	10.2
Unilateral on right	29	3.5	16	1.9	2	0.2
Unilateral on left	18	2.2	7	0.8	3	0.3
Reverse overjet	11	1.3	18	2.1	15	1.7
Posterior occlusion						
Right crossbite	60	7.8	60	7.2	59	7.0
Left crossbite	55	7.2	48	5.8	51	6.0
Unilateral (right or left)	80	10.5	89	10.8	98	11.6
Bilateral (right and left)	17	2.2	9	1.1	6	0.7
Open bite AND crossbite	102	12.6	118	14.2	65	7.6
Tongue-tie	5	0.6	4	0.5	7	0.8

Table 8.2: **Proportion of children with a spaced upper labial segment at 31-months (U 31) by proportion with a spaced upper labial segment at 43-months (U 43)**

n=797 100%	U 43 Not spaced 438 55%	U 43 Spaced 359 45%	χ^2	p value
U 31 Not spaced 486 61%	368 75.7%	118 24.3%	217	<0.0001
U 31 Spaced 311 39%	70 22.5%	241 77.5%		

Table 8.3: **Proportion of children with a spaced upper labial segment at 31-months (U 31) by proportion with a spaced upper labial segment at 61-months (U 61)**

n=797 100%	U 61 Not spaced 416 52.2%	U 61 Spaced 381 47.8%	χ^2	p value
U 31 Not spaced 486 61%	347 71.4%	139 28.6%	184	<0.0001
U 31 Spaced 311 39%	69 22.2%	242 77.8%		

Table 8.4: **Proportion of children with a spaced upper labial segment at 43-months (U 43) by proportion with a spaced upper labial segment at 61-months (U 61)**

n=797 100%	U 61 Not spaced 416 52.2%	U 61 Spaced 381 47.8%	χ^2	p value
U 43 Not spaced 438 55%	342 78.1%	96 21.9%	261	<0.0001
U 43 Spaced 359 45%	74 20.6%	285 79.4%		

Table 8.5: **Proportion of children with a spaced lower labial segment at 31-months (L 31) by proportion with a spaced lower labial segment at 43-months (L 43)**

n=799 100%	L 43 Not spaced 400 50.1%	L 43 Spaced 399 49.9%	χ^2	p value
L 31 Not spaced 470 58.8%	328 69.8%	42 30.2%	178	<0.0001
L 31 Spaced 329 41.2%	72 21.9%	257 78.1%		

Table 8.6: **Proportion of children with a spaced lower labial segment at 31-months (L 31) by proportion with a spaced lower labial segment at 61-months (L 61)**

n=799 100%	L 61 Not spaced 353 44.2%	L 61 Spaced 446 55.8%	χ^2	p value
L 31 Not spaced 470 58.8%	296 63.0%	174 37.0%	164	<0.0001
L 31 Spaced 329 41.2%	57 17.3%	272 82.7%		

Table 8.7: **Proportion of children with a spaced lower labial segment at 43-months (L 43) by proportion with a spaced lower labial segment at 61-months (L 61)**

n=799 100%	L 61 Not spaced 353 44.2%	L 61 Spaced 446 55.8%	χ^2	p value
L 43 Not spaced 400 50.1%	293 73.3%	107 26.7%	274	<0.0001
L 43 Spaced 399 49.9%	60 15.0%	339 85.0%		

Table 8.8: Proportion of children with a spaced upper labial segment at 31-months (U 31) by proportion with spaced lower labial segment at 31-months (L 31)

n=827	L 31 Not spaced 490 59.3%	L 31 Spaced 337 40.7%	χ^2	p value
U 31 Not spaced 510 61.7%	402 78.8%	108 21.2%	211	<0.0001
U 31 Spaced 317 38.3%	88 27.8%	229 72.2%		

Table 8.9: Proportion of children with a spaced upper labial segment at 43-months (U 43) by proportion with spaced lower labial segment at 43-months (L 43)

n=844	L 43 Not spaced 430 50.9%	L 43 Spaced 414 49.1%	χ^2	p value
U 43 Not spaced 462 54.7%	329 71.2%	133 28.8%	168	<0.0001
U 43 Spaced 382 45.3%	101 26.4%	281 73.6%		

Table 8.10: Proportion of children with a spaced upper labial segment at 61-months (U 61) by proportion with spaced lower labial segment at 61-months (L 61)

n=835	L 61 Not spaced 376 45.0%	L 61 Spaced 459 55.0%	χ^2	p value
U 61 Not spaced 432 51.7%	294 68.1%	138 31.9%	192	<0.0001
U 61 Spaced 403 48.3%	82 20.3%	321 79.7%		

Table 8.11: Proportion of children with open bite at 31-months (A 31) by proportion with open bite at 43-months (A 43)

n=783	A 43 No open bite 632 80.7%	A 43 Open bite 151 19.3%	χ^2	p value
A 31 No open bite 615 78.5%	567 92.2%	48 7.8%	243	<0.0001
A 31 Open bite 168 21.5%	65 38.7%	103 61.3%		

Table 8.12: Proportion of children with open bite at 31-months (A 31) by proportion with open bite at 61-months (A 61)

n=783	A 61 No open bite 701 89.5%	A 61 Open bite 82 10.5%	χ^2	p value
A 31 No open bite 615 78.5%	578 94.0%	37 6.0%	61	<0.0001
A 31 Open bite 168 21.5%	123 73.2%	45 26.8%		

Table 8.13: Proportion of children with open bite at 43-months (A 43) by proportion with open bite at 61-months (A 61)

n=783	A 61 No open bite 701 89.5%	A 61 Open bite 82 10.5%	χ^2	p value
A 43 No open bite 632 80.7%	611 96.7%	21 3.3%	179	<0.0001
A 43 Open bite 151 19.3%	90 59.6%	61 40.4%		

Table 8.14: Proportion of children with reverse overjet at 31-months (ROJ 31) by proportion with reverse overjet at 43-months (ROJ 43)

n=799	ROJ 43 No reverse overjet 782 97.9%	ROJ 43 Reverse overjet 17 2.1%	χ^2	p value
ROJ 31 No reverse overjet 788 98.6%	780 99.0%	8 1.0%	340	<0.0001
ROJ 31 Reverse overjet 11 1.4%	2 18.2%	9 81.8%		

Table 8.15: Proportion of children with reverse overjet at 31-months (ROJ 31) by proportion with reverse overjet at 61-months (ROJ 61)

n=799	ROJ 61 No reverse overjet 785 98.2%	ROJ 61 Reverse overjet 14 1.8%	χ^2	p value
ROJ 31 No reverse overjet 788 98.6%	781 99.1%	7 0.9%	248	<0.0001
ROJ 31 Reverse overjet 11 1.4%	4 36.4%	7 63.6%		

Table 8.16: Proportion of children with reverse overjet at 43-months (ROJ 43) by proportion with reverse overjet at 61-months (ROJ 61)

n=799	ROJ 61 No reverse overjet 785 98.2%	ROJ 61 Reverse overjet 14 1.8%	χ^2	p value
ROJ 43 No reverse overjet 782 97.9%	776 99.2%	6 0.8%	207	<0.0001
ROJ 43 Reverse overjet 17 2.1%	9 52.9%	8 47.1%		

Table 8.17: Proportion of children with posterior crossbite at 31-months (Xbite 31) by proportion with posterior crossbite at 43-months (Xbite 43)

n=713	Xbite 43 No crossbite 627 87.9%	Xbite 43 Crossbite 86 12.1%	χ^2	p value
Xbite 31 No crossbite 627 87.9%	574 91.5%	53 8.5%	64	<0.0001
Xbite 31 Crossbite 86 12.1%	53 61.6%	33 38.4%		

Table 8.18: Proportion of children with posterior crossbite at 43-months (Xbite 43) by proportion with posterior crossbite at 61-months (Xbite 61)

n=713	Xbite 61 No crossbite 629 88.2%	Xbite 61 Crossbite 84 11.8%	χ^2	p value
Xbite 43 No crossbite 627 87.9%	598 95.4%	29 4.6%	256	<0.0001
Xbite 43 Crossbite 86 12.1%	31 36%	55 64%		

Table 8.19: Proportion of children with posterior crossbite at 31-months (Xbite 31) by proportion with posterior crossbite at 61-months (Xbite 61)

n=713	Xbite 61 No crossbite 629 88.2%	Xbite 61 Crossbite 84 11.8%	χ^2	p value
Xbite 31 No crossbite 627 87.9%	579 92.3%	48 7.7%	85	<0.0001
Xbite 31 Crossbite 86 12.1%	50 58.1%	36 41.9%		

Table 8.20: Proportion of children with open bite at 31-months (A 31) by proportion with posterior crossbite at 31-months (Xbite 31)

n=754	Xbite 31 No crossbite 659 87.4%	Xbite 31 Crossbite 95 12.6%	χ^2	p value
A 31 No open bite 587 77.9%	557 94.9%	30 5.1%	135	<0.0001
Xbite 31 Open bite 167 22.1%	102 61.1%	65 38.9%		

Table 8.21: Proportion of children with open bite at 43-months (A 43) by proportion with posterior crossbite at 43-months (Xbite 43)

n=809	Xbite 43 No crossbite 713 88.1%	Xbite 43 Crossbite 95 12.6%	χ^2	p value
A 43 No open bite 651 80.5%	595 91.4%	56 8.6%	34	<0.0001
Xbite 43 Open bite 158 19.5%	118 74.7%	40 25.3%		

Table 8.22: Proportion of children with open bite at 61-months (A 61) by proportion with posterior crossbite at 61-months (Xbite 61)

n=809	Xbite 61 No crossbite 736 87.7%	Xbite 61 Crossbite 103 12.3%	χ^2	p value
A 61 No open bite 749 89.3%	671 89.6%	78 10.4%	22	<0.0001
Xbite 61 Open bite 90 10.7%	65 72.2%	25 27.8%		

Table 8.23: Proportion of 867 children at each age with a reported sucking habit

	n	Dummy	Digit	Both	Neither or missing cases
15-months	867	310 (37.6%)	188 (22.8%)	24 (2.8%)	369 (42.6%)
24-months	867	269 (34.6%)	153 (21.2%)	8 (1.2%)	422 (48.6%)
36-months	867	140 (18.3%)	144 (18.9%)	13 (1.8%)	583 (67.2%)

Table 8.24: Proportion of children with digit sucking habit at 15-months by proportion of children with spaced upper labial segment (U) at 31-, 43- and 61-months

		No digit sucking habit @15 mths		Digit sucking habit @15 mths		χ^2	p value
U31	n=798 100.0%	614	76.9%	184	23.1%	1	0.288^{NS}
	Not spaced 495 (62.0%)	387	63.0%	108	58.7%		
	Spaced 303 (38.0%)	227	37.0%	76	41.3%		
U43	n=804 100.0%	621	77.2%	183	22.8%	4	0.035*
	Not spaced 437 (54.4%)	350	56.4%	87	47.5%		
	Spaced 367 (45.6%)	271	43.6%	96	52.5%		
U61	n=804 100.0%	619	77.0%	185	23.0%	6	0.017*
	Not spaced 414 (51.5%)	333	53.8%	81	43.8%		
	Spaced 390 (48.5%)	286	46.2%	104	56.2%		

NS p>0.05 * p<0.05

Table 8.25: Proportion of children with digit sucking habit at 15-months by proportion of children with spaced lower labial segment (L) at 31-, 43- and 61-months

		No digit sucking habit @15 mths		Digit sucking habit @15 mths		χ^2	p value
L31	n=792 100.0%	611	77.1%	181	22.9%	0.2	0.649^{NS}
	Not spaced 471 (59.5%)	366	59.9%	105	58.0%		
	Spaced 321 (40.5%)	245	40.1%	76	42.0%		
L43	n=807 100.0%	623	77.2%	184	22.8%	1	0.301^{NS}
	Not spaced 413 (51.2%)	325	52.2%	88	47.8%		
	Spaced 394 (48.8%)	298	47.8%	96	52.2%		
L61	n=810 100.0%	623	76.9%	187	23.1%	0.1	0.733^{NS}
	Not spaced 364 (44.9%)	282	45.3%	82	43.9%		
	Spaced 446 (55.1%)	341	54.7%	105	56.1%		

NS p>0.05

Table 8.26: Proportion of children with digit sucking habit at 15-months by proportion of children with open bite (A) at 31-, 43- and 61-months

		No digit sucking habit @15 mths		Digit sucking habit @15 mths		χ^2	p value
A31	n=777 100.0%	600	77.2%	177	22.8%	0.6	0.438^{NS}
	Normal 616 (77.2%)	472	78.7%	144	81.4%		
	Affected 161 (20.7%)	128	21.3%	33	18.6%		
A43	n=796 100.0%	615	77.3%	181	22.7%	4	0.055^{NS}
	Normal 646 (81.2%)	508	82.6%	138	76.2%		
	Affected 150 (18.8%)	107	17.4%	43	23.8%		
A61	n=815 100.0%	629	77.2%	186	22.8%	21	<0.0001
	Normal 731 (89.7%)	581	92.4%	150	80.6%		
	Affected 84 (10.3%)	48	7.6%	36	19.4%		

NS p>0.05

Table 8.27: Proportion of children with digit sucking habit at 15-months by proportion of children with posterior crossbite (Xbite) at 31-, 43- and 61-months

		No digit sucking habit @15 mths		Digit sucking habit @15 mths		χ^2	p value
Xbite 31	n=725 100.0%	562	77.5%	163	22.5%	0.6	0.448^{NS}
	Normal 637 (87.9%)	491	87.4%	146	89.6%		
	Affected 88 (12.1%)	71	12.6%	17	10.4%		
Xbite 43	n=780 100.0%	605	77.6%	175	22.4%	0.4	0.520^{NS}
	Normal 684 (87.7%)	533	88.1%	151	86.3%		
	Affected 96 (12.3%)	72	11.9%	24	13.7%		
Xbite 61	n=803 100.0%	625	77.8%	178	22.2%	2.4	0.118^{NS}
	Normal 704 (87.7%)	554	88.6%	150	84.3%		
	Affected 99 (12.3%)	71	11.4%	28	15.7%		

NS $p>0.05$

Table 8.28: Proportion of children with digit sucking habit at 24-months by proportion of children with spaced upper labial segment (U) at 31-, 43- and 61-months

		No digit sucking habit @24 mths		Digit sucking habit @24 mths		χ^2	p value
U31	n=696 100.0%	548	78.7%	148	21.3%	4	0.036*
	Not spaced 428 (61.5%)	348	63.5%	80	54.1%		
	Spaced 268 (38.5%)	200	36.5%	68	45.9%		
U43	n=704 100.0%	556	79.0%	148	21.0%	10	0.002**
	Not spaced 380 (54.0%)	317	57.0%	63	42.6%		
	Spaced 324 (46.0%)	239	43.0%	85	57.4%		
U61	n=702 100.0%	552	78.6%	150	21.4%	5	0.023*
	Not spaced 348 (49.6%)	286	51.8%	62	41.3%		
	Spaced 354 (50.4%)	266	48.2%	88	58.7%		

* $p<0.05$ ** $p<0.01$

Table 8.29: Proportion of children with digit sucking habit at 24-months by proportion of children with spaced lower labial segment (L) at 31-, 43- and 61-months

		No digit sucking habit @24 mths		Digit sucking habit @24 mths		χ^2	p value
L31	n=691 100.0%	546	79.0%	145	21.0%	0.2	0.683^{NS}
	Not spaced 420 (60.8%)	334	61.2%	86	59.3%		
	Spaced 271 (39.2%)	212	38.8%	59	40.7%		
L43	n=705 100.0%	556	78.9%	149	21.1%	0.6	0.451^{NS}
	Not spaced 360 (51.1%)	288	51.8%	72	48.3%		
	Spaced 345 (48.9%)	268	48.2%	77	51.7%		
L61	n=711 100.0%	559	78.6%	152	21.4%	0.6	0.424^{NS}
	Not spaced 315 (44.3%)	252	45.1%	63	41.4%		
	Spaced 396 (55.7%)	307	54.9%	89	58.6%		

NS $p>0.05$

Table 8.30: Proportion of children with digit sucking habit at 24-months by proportion of children with open bite (A) at 31-, 43- and 61-months

		No digit sucking habit @24 mths		Digit sucking habit @24 mths		χ^2	p value
A31	n=678 100.0%	537	79.2%	141	20.8%	0.3	0.559[NS]
	Normal 561 (82.7%)	442	82.3%	119	84.4%		
	Affected 117 (17.3%)	95	17.7%	22	15.6%		
A43	n=695 100.0%	548	78.8%	147	21.2%	10	0.002**
	Normal 583 (83.9%)	472	86.1%	111	75.5%		
	Affected 112 (16.1%)	76	13.9%	36	24.5%		
A61	n=712 100.0%	561	78.8%	151	21.2%	34	<0.0001
	Normal 646 (90.7%)	527	93.9%	119	78.8%		
	Affected 66 (9.3%)	34	6.1%	32	21.2%		

NS p>0.05 ** p<0.01

Table 8.31: Proportion of children with digit sucking habit at 24-months by proportion of children with posterior crossbite (Xbite) at 31-, 43- and 61-months

		No digit sucking habit @24 mths		Digit sucking habit @24 mths		χ^2	p value
Xbite 31	n=633 100.0%	501	79.1%	132	20.9%	0.004	0.952[NS]
	Normal 562 (88.8%)	445	88.8%	117	88.6%		
	Affected 71 (11.2%)	56	11.2%	15	11.4%		
Xbite 43	n=685 100.0%	541	79.0%	144	21.0%	0.093	0.76[NS]
	Normal 609 (88.9%)	482	89.1%	127	88.2%		
	Affected 76 (11.1%)	59	10.9%	17	11.8%		
Xbite 61	n=701 100.0%	557	79.5%	144	20.5%	3	0.066[NS]
	Normal 628 (89.6%)	505	90.7%	123	85.4%		
	Affected 73 (10.4%)	52	9.3%	21	14.6%		

NS $p>0.05$

Table 8.32: Proportion of children with digit sucking habit at 36-months by proportion of children with spaced upper labial segment (U) at 43- and 61-months

		No digit sucking habit @36 mths		Digit sucking habit @36 mths		χ^2	p value
U43	n=744 100.0%	605	81.3%	139	18.7%	5	0.022*
	Not spaced 402 (54.0%)	339	56.0%	63	45.3%		
	Spaced 342 (46.0%)	266	44.0%	76	54.7%		
U61	n=745 100.0%	605	81.2%	140	18.8%	0.8	0.363^{NS}
	Not spaced 377 (50.6%)	311	51.4%	66	47.1%		
	Spaced 368 (49.4%)	294	48.6%	74	52.9%		

NS p>0.05 * p<0.05

Table 8.33: Proportion of children with digit sucking habit at 36-months by proportion of children with spaced lower labial segment (L) at 43- and 61-months

		No digit sucking habit @36 mths		Digit sucking habit @36 mths		χ^2	p value
L43	n=746 100.0%	607	81.4%	139	18.6%	0.01	0.918^{NS}
	Not spaced 384 (51.5%)	313	51.6%	71	51.1%		
	Spaced 362 (48.5%)	294	48.4%	68	48.9%		
L61	n=751 100.0%	609	81.1%	142	18.9%	0.002	0.966^{NS}
	Not spaced 332 (44.2%)	269	44.2%	63	44.4%		
	Spaced 419 (55.8%)	340	55.8%	79	55.6%		

NS p>0.05

Table 8.34: Proportion of children with digit sucking habit at 36-months by proportion of children with open bite (A) at 43- and 61-months

		No digit sucking habit @36 mths		Digit sucking habit @36 mths		χ^2	p value
A43	n=735 100.0%	598	81.4%	137	18.6%	15	<0.0001
	Normal 613 (83.4%)	514	86.0%	99	72.3%		
	Affected 122 (16.6%)	84	14.0%	38	27.7%		
A61	n=754 100.0%	612	81.2%	142	18.8%	37	<0.0001
	Normal 681 (90.3%)	572	93.5%	109	76.8%		
	Affected 73 (9.7%)	40	6.5%	33	23.2%		

Table 8.35: Proportion of children with digit sucking habit at 36-months by proportion of children with posterior crossbite (Xbite) at 43- and 61-months

		No digit sucking habit @36 mths		Digit sucking habit @36 mths		χ^2	p value
Xbite43	n=719 100.0%	585	81.4%	134	18.6%	5	0.029*
	Normal 635 (88.3%)	524	89.6%	111	82.8%		
	Affected 84 (11.7%)	61	10.4%	23	17.2%		
Xbite61	n=741 100.0%	604	81.5%	137	18.5%	9	0.003**
	Normal 655 (88.4%)	544	90.1%	111	81.0%		
	Affected 86 (11.6%)	60	9.9%	26	19.0%		

* $p<0.05$ ** $p<0.01$

Table 8.36: Proportion of children with persistent digit sucking habit by proportion of children with spaced upper labial segment (U) at 43- and 61-months

		Sucked at digit at one or less time-point		Sucked digit at two or more time-points		χ^2	p value
U 43	n=795	674	84.8%	121	15.2%	10	0.001***
	Not spaced 429 54.0%	380	56.4%	49	40.5%		
	Spaced 366 46.0%	294	43.6%	72	59.5%		
U 61	n=795	671	84.4%	124	15.6%	6	0.013*
	Not spaced 408 51.3%	357	53.2%	51	41.1%		
	Spaced 387 48.7%	314	46.8%	73	58.9%		

* $p<0.05$ *** $p<0.001$

Table 8.37: Proportion of children with persistent digit sucking habit by proportion of children with spaced lower labial segment (L) at 43- and 61-months

		Sucked at digit at one or less time-point		Sucked digit at two or more time-points		χ^2	p value
L 43	n=798	676	84.7%	122	15.3%	2	0.204 NS
	Not spaced 402 50.4%	347	51.3%	55	45.1%		
	Spaced 396 49.6%	329	48.7%	67	54.9%		
L 61	n=803	677	84.3%	126	15.7%	1	0.415 NS
	Not spaced 358 44.6%	302	45.2%	52	41.3%		
	Spaced 445 55.4%	371	54.8%	74	58.7%		

NS $p>0.05$

Table 8.38: Proportion of children with persistent digit sucking habit by proportion of children with open bite (A) at 43- and 61-months

		Sucked digit at one or less time-point		Sucked digit at two or more time-points		χ^2	p value
A 43	n=787	667	84.8%	120	15.2%	5	0.029*
	No open bite 640 81.3%	551	82.6%	89	74.2%		
	Open bite 147 18.7%	116	17.4%	31	25.8%		
A 61	n=787	682	84.5%	125	15.5%	22	<0.0001
	No open bite 640 81.3%	628	92.1%	98	78.4%		
	Open bite 147 18.7%	54	7.9%	27	21.6%		

* $p<0.05$

Table 8.39: Proportion of children with persistent digit sucking habit by proportion of children with posterior crossbite (Xbite) at 43- and 61-months

		Sucked at digit at one or less time-point		Sucked digit at two or more time-points		χ^2	p value
Xbite 43	n=771	654	84.8%	117	15.2%	1	0.347^{NS}
	No crossbite 679 88.1%	579	88.5%	100	85.5%		
	Crossbite 92 11.9%	75	11.5%	17	14.5%		
Xbite 61	n=795	677	85.2%	118	14.8%	4	0.044*
	No crossbite 698 87.8%	601	88.8%	97	82.2%		
	Crossbite 97 12.2%	76	11.2%	21	17.8%		

NS $p>0.05$ * $p<0.05$

Table 8.40: Proportion of children with dummy sucking habit at 15-months by proportion of children with spaced upper labial segment (U) at 31-, 43- and 61-months

		No dummy sucking habit @15 mths		Dummy sucking habit @15 mths		χ^2	p value
U31	n=798 100.0%	500	62.7%	298	37.3%	0.2	0.635^{NS}
	Not spaced 495 (62.0%)	307	61.4%	188	63.1%		
	Spaced 303 (38.0%)	193	38.6%	110	36.9%		
U43	n=804 100.0%	502	62.4	302	37.6%	3.5	0.06^{NS}
	Not spaced 437 (54.4%)	260	51.8%	177	58.6%		
	Spaced 367 (45.6%)	242	48.2%	125	41.4%		
U61	n=804 100.0%	504	62.7%	300	37.3%	23	<0.0001
	Not spaced 414 (51.5%)	227	45.0%	187	62.3%		
	Spaced 390 (48.5%)	277	55.0%	113	37.7%		

NS p>0.05

Table 8.41: Proportion of children with dummy sucking habit at 15-months by proportion of children with spaced lower labial segment (L) at 31-, 43- and 61-months

		No dummy sucking habit @15 mths		Dummy sucking habit @15 mths		χ^2	p value
L31	n=792 100.0%	497	62.8%	295	37.2%	13	<0.0001
	Not spaced 471 (59.5%)	320	64.4%	151	51.2%		
	Spaced 321 (40.5%)	177	35.6%	144	48.8%		
L43	n=807 100.0%	503	62.3%	304	37.7%	1	0.271^{NS}
	Not spaced 413 (51.2%)	265	52.7%	148	48.7%		
	Spaced 394 (48.8%)	238	47.3%	156	51.3%		
L61	n=810 100.0%	508	62.7%	302	37.3%	0.1	0.738^{NS}
	Not spaced 364 (44.9%)	226	44.5%	138	45.7%		
	Spaced 446 (55.1%)	282	55.5%	164	54.3%		

NS p>0.05

Table 8.42: Proportion of children with dummy sucking habit at 15-months by proportion of children with open bite (A) at 31-, 43- and 61-months

		No dummy sucking habit @15 mths		Dummy sucking habit @15 mths		χ^2	p value
A31	n=777 100.0%	483	62.2%	294	37.8%	168	<0.0001
	Normal 616 (79.3%)	454	94.0%	162	55.1%		
	Affected 161 (20.7%)	29	6.0%	132	44.9%		
A43	n=796 100.0%	496	62.3%	300	37.7%	100	<0.0001
	Normal 646 (81.2%)	456	91.9%	190	63.3%		
	Affected 150 (18.8%)	40	8.1%	110	36.7%		
A61	n=815 100.0%	511	62.7%	304	37.3%	9	0.003**
	Normal 731 (89.7%)	471	92.2%	260	85.5%		
	Affected 84 (10.3%)	40	7.8%	44	14.5%		

** p<0.01

Table 8.43: Proportion of children with dummy sucking habit at 15-months by proportion of children with posterior crossbite (Xbite) at 31-, 43- and 61-months

		No dummy sucking habit @15 mths		Dummy sucking habit @15 mths		χ^2	p value
Xbite 31	n=725 100.0%	449	61.9%	276	38.1%	36	<0.0001
	Normal 637 (87.1%)	420	93.5%	217	78.6%		
	Affected 88 (12.1%)	29	6.5%	59	21.4%		
Xbite 43	n=780 100.0%	486	62.3%	294	37.7%	29	<0.0001
	Normal 684 (87.7%)	450	92.6%	234	79.6%		
	Affected 96 (12.3%)	36	7.4%	60	20.4%		
Xbite 61	n=803 100.0%	499	62.1%	304	37.9%	27	<0.0001
	Normal 704 (87.7%)	461	92.4%	243	79.9%		
	Affected 99 (12.3%)	38	7.6%	61	20.1%		

Table 8.44: Proportion of children with dummy sucking habit at 24-months by proportion of children with spaced upper labial segment (U) at 31-, 43- and 61-months

		No dummy sucking habit @24 mths		Dummy sucking habit @24 mths		χ^2	p value
U31	n=751 100.0%	491	65.4%	260	34.6%	0.02	0.877^{NS}
	Not spaced 468 (62.3%)	305	62.1%	163	62.7%		
	Spaced 283 (37.7%)	186	37.9%	97	37.3%		
U43	n=760 100.0%	496	65.3%	264	34.7%	6	0.012^{*}
	Not spaced 425 (55.9%)	261	52.6%	164	62.1%		
	Spaced (44.1%)	235	47.4%	100	37.9%		
U61	n=756 100.0%	498	65.9%	258	34.1%	24	<0.0001
	Not spaced 395 (52.2%)	228	45.8%	167	64.7%		
	Spaced 361 (47.8%)	270	54.2%	91	35.3%		

NS $p>0.05$ * $p<0.05$

Table 8.45: Proportion of children with dummy sucking habit at 24-months by proportion of children with spaced lower labial segment (L) at 31-, 43- and 61-months

		No dummy sucking habit @24 mths		Dummy sucking habit @24 mths		χ^2	p value
L31	n=747 100.0%	489	65.5%	258	34.5%	15	<0.0001
	Not spaced 440 (58.9%)	313	64.0%	127	49.2%		
	Spaced 307 (41.1%)	176	36.0%	131	50.8%		
L43	n=761 100.0%	495	65.0%	266	35.0%	0.9	0.340^{NS}
	Not spaced 387 (50.9%)	258	52.1%	129	48.5%		
	Spaced 374 (49.1%)	237	47.9%	137	51.5%		
L61	n=762 100.0%	502	65.9%	260	34.1%	0.4	0.508^{NS}
	Not spaced 342 (44.9%)	221	44.0%	121	46.5%		
	Spaced 420 (55.1%)	281	56.0%	139	53.5%		

NS p>0.05

Table 8.46: Proportion of children with dummy sucking habit at 24-months by proportion of children with open bite (A) at 31-, 43- and 61-months

		No dummy sucking habit @24 mths		Dummy sucking habit @24 mths		χ^2	p value
A31	n=733 100.0%	477	65.1%	256	34.9%	213	<0.0001
	Normal 582 (79.4%)	455	95.4%	127	49.6%		
	Affected 151 (20.6%)	22	4.6%	129	50.4%		
A43	n=750 100.0%	487	64.9%	263	35.1%	155	<0.0001
	Normal 607 (80.9%)	458	94.0%	149	56.7%		
	Affected 143 (19.1%)	29	6.0%	114	43.3%		
A61	n=768 100.0%	504	65.6%	264	34.4%	24	<0.0001
	Normal 695 (90.5%)	475	94.2%	220	83.3%		
	Affected 73 (9.5%)	29	5.8%	44	16.7%		

Table 8.47: Proportion of children with dummy sucking habit at 24-months by proportion of children with posterior crossbite (Xbite) at 31-, 43- and 61-months

		No dummy sucking habit @24 mths		Dummy sucking habit @24 mths		χ^2	p value
Xbite 31	n=682 100.0%	444	93.5%	238	34.9%	36	<0.0001
	Normal 600 (88.0%)	415	93.5%	185	77.7%		
	Affected 82 (12.0%)	29	6.5%	53	22.3%		
Xbite 43	n=735 100.0%	478	65.0%	257	35.0%	45	<0.0001
	Normal 647 (88.0%)	449	93.9%	198	77.0%		
	Affected 88 (12.0%)	29	6.1%	59	23.0%		
Xbite 61	n=761 100.0%	497	65.3%	264	34.7%	44	<0.0001
	670 (88.0%)	466	93.8%	204	77.3%		
	Affected 91 (12.0%)	31	6.2%	60	22.7%		

Table 8.48: Proportion of children with dummy sucking habit at 36-months by proportion of children with spaced upper labial segments (U) at 43- and 61-months

		No dummy sucking habit @36 mths		Dummy sucking habit @36 mths		χ^2	p value
U43	n=755 100%	617	81.7%	138	18.3%	0.3	0.586[NS]
	Not spaced 411 (54.4%)	333	54.0%	78	56.5%		
	Spaced 344 (45.6%)	284	46.0%	60	43.5%		
U61	n=754 100%	624	82.8%	130	17.2%	15	<0.0001
	Not spaced 394 (52.3%)	306	49.0%	88	67.7%		
	Spaced 360 (47.7%)	618	51.0%	42	32.3%		

NS p>0.05

Table 8.49: Proportion of children with dummy sucking habit at 36-months by proportion of children with spaced lower labial segments (L) at 43- and 61-months

		No dummy sucking habit @36 mths		Dummy sucking habit @36 mths		χ^2	p value
L43	n=757 100%	617	81.5%	140	18.5%	12	0.001***
	Not spaced 380 (50.2%)	328	53.2%	52	37.1%		
	Spaced 377 (49.8%)	289	46.8%	88	62.9%		
L61	n=759 100%	627	82.6%	132	17.4%	0.01	0.907[NS]
	Not spaced 337 (44.4%)	279	44.5%	58	43.9%		
	Spaced 422 (55.6%)	348	55.5%	74	56.1%		

NS p>0.05 *** p<0.001

Table 8.50: Proportion of children with dummy sucking habit at 36-months by proportion of children with open bite (A) at 43- and 61-months

		No dummy sucking habit @36 mths		Dummy sucking habit @36 mths		χ^2	p value
A43	n=747 100.0%	610	81.7%	137	18.3%	316	<0.0001
	Normal 602 (80.6%)	566	92.8%	36	26.3%		
	Affected 145 (19.4%)	44	7.2%	101	73.7%		
A61	n=764 100.0%	628	82.2%	136	17.8%	60	<0.0001
	Normal 691 (90.4%)	592	94.3%	99	72.8%		
	Affected 73 (9.6%)	36	5.7%	37	27.2%		

Table 8.51: Proportion of children with dummy sucking habit at 36-months by proportion of children with posterior crossbite (Xbite) at 43- and 61-months

		No dummy sucking habit @36 mths		Dummy sucking habit @36 mths		χ^2	p value
Xbite43	n=730 100.0%	596	81.6%	134	18.4%	28	<0.0001
	Normal 643 (88.1%)	543	91.1%	100	74.6%		
	Affected 87 (11.9%)	53	8.9%	34	39.1%		
Xbite61	n=751 100.0%	615	81.9%	136	18.1%	36	<0.0001
	Normal 664 (88.4%)	564	91.7%	100	73.5%		
	Affected 87 (11.6%)	51	8.3%	36	26.5%		

Table 8.52: Proportion of children with persistent dummy sucking habit by proportion of children with spaced upper labial segments (U) at 43- and 61-months

		Sucked at dummy at one or less time-point		Sucked dummy at two or more time-points		χ^2	p value
U 43	n=744	489	65.7%	255	34.3%	5	0.032*
	Not spaced 415 55.8%	259	53.0%	156	61.2%		
	Spaced 329 44.2%	230	47.0%	99	38.8%		
U 61	n=741	492	66.4%	249	33.6%	23	<0.0001
	Not spaced 387 52.2%	226	45.9%	161	64.7%		
	Spaced 354 47.8%	266	54.1%	88	35.3%		

* $p<0.05$

Table 8.53: Proportion of children with persistent dummy sucking habit by proportion of children with spaced lower labial segments (L) at 43- and 61-months

		Sucked at dummy at one or less time-point		Sucked dummy at two or more time-points		χ^2	p value
L 43	n=746	489	65.5%	257	34.5%	1	0.263 NS
	Not spaced 381 51.1%	257	52.6%	124	48.2%		
	Spaced 365 48.9%	232	47.4%	133	51.8%		
L 61	n=747	495	66.3%	252	33.7%	0.4	0.535 NS
	Not spaced 335 44.8%	218	44.0%	117	46.4%		
	Spaced 412 55.2%	277	56.0%	135	53.6%		

NS $p>0.05$

Table 8.54: Proportion of children with persistent dummy sucking habit by proportion of children with open bite (A) at 43- and 61-months

		Sucked dummy at one or less time-point		Sucked dummy at two or more time-points		χ^2	p value
A 43	n=718	470	65.5%	248	34.5%	219	<0.0001
	No open bite 569 79.2%	449	95.5%	120	48.4%		
	Open bite 149 20.8%	21	4.5%	128	51.6%		
A 61	n=753	498	66.1%	255	33.9%	25	<0.0001
	No open bite 682 90.6%	470	94.4%	212	83.1%		
	Open bite 71 9.4%	28	5.6%	43	16.9%		

Table 8.55: Proportion of children with persistent dummy sucking habit by proportion of children with posterior crossbite (Xbite) at 43- and 61-months

		Sucked dummy at one or less time-point		Sucked dummy at two or more time-points		χ^2	p value
Xbite 43	n=719	471	65.5%	248	34.5%	45	<0.0001
	No crossbite 632 87.9%	442	93.8%	190	76.6%		
	Crossbite 87 12.1%	29	6.2%	58	23.4%		
Xbite 61	n=795	490	65.8%	255	34.2%	45	<0.0001
	No crossbite 655 87.9%	459	93.7%	196	76.9%		
	Crossbite 90 12.1%	31	6.3%	59	23.1%		

Table 8.56: Proportion of children within each home ownership group by proportion of children with persistent sucking habits

		Home ownership (mortgaged or owned)		Home ownership (Council or rented)		χ^2	p value
Persistent digit	n=807 100.0%	674	83.5%	133	16.5%	1.5	0.213
	Yes 126 (15.6%)	110	16.3%	16	12.0%		
	No 681 (84.4%)	564	83.7%	117	88.0%		
Persistent dummy	n=753 100.0%	628	83.4%	125	16.6%	2	0.191
	Yes 257 (34.1%)	208	33.1%	49	39.2%		
	No 496 (65.9%)	420	66.9%	76	60.8%		

Table 8.57: Proportion of children within each maternal education group by proportion of children with persistent sucking habits

		Maternal education (up to O level)		Maternal education (Higher education)		χ^2	p value
Persistent digit	n=806 100.0%	452	56.1%	354	43.9%	1	0.362
	Yes 126 (15.6%)	66	14.6%	60	16.9%		
	No 680 (84.4%)	386	85.4%	294	83.1%		
Persistent dummy	n=752 100.0%	417	55.5%	335	44.5%	11	0.001
	Yes 258 (34.3%)	165	39.6%	93	27.8%		
	No 494 (65.7%)	252	60.4%	242	72.2%		

Table 8.58: Proportion of children within each maternal age group by proportion of children with persistent sucking habits

		Maternal age at delivery (16-29)		Maternal age at delivery (>29)		χ^2	p value
Persistent digit	n=816 100.0%	426	52.2%	390	47.8%	1	0.262
	Yes 126 (15.4%)	60	14.1%	66	16.9%		
	No 690 (84.6%)	366	85.9%	324	83.1%		
Persistent dummy	n=761 100.0%	401	52.7%	360	47.3%	10	0.001
	Yes 260 (34.2%)	158	39.4%	102	28.3%		
	No 501 (65.8%)	243	60.6%	258	71.7%		

CHAPTER 9

DISCUSSION

9.1 Introduction

The population in this study has been shown to be representative of that in the rest of Great Britain (Section 2.1), although significantly fewer children were living in rented accommodation compared with the rest of the country (ALSPAC Study Team 2000). In the most recent Child Dental Health survey (O'Brien 1994), the mean *dmft* of 5-year-olds in England and Wales was 2.0 and 55% of children were caries-free, whilst in Bristol and District, the mean *dmft* was 0.92, with 70% caries-free. This suggests that children within the ALSPAC study group may be at less risk of developing dental caries than children living in other areas of the UK.

The study used longitudinal data to report the development of dental disease and stages of occlusal development in children from 31- to 61-months of age. The influence of socio-demographic factors and diet on the presence of caries was investigated. Longitudinal data concerning a history of non-nutritive sucking habits up to 36-months of age were also available and the influence of these sucking habits on the development of occlusion was considered. Dental erosion was recorded when the children were 61-months old and the presence of erosion and its association with the frequency of consumption of fruit drinks was reported.

The Avon Longitudinal Study of Pregnancy and Childhood has limited financial resource and therefore, to keep costs to a minimum, non-dental health care professionals were trained to collect the clinical dental data. A reproducibility study was carried out during data collection and the conclusions drawn from that study influenced the way in which the data were analysed.

9.2 Data collection

It would have been desirable to use well-established dental survey criteria in this study to allow comparison between these data and those of other studies, such as the Child Dental Health surveys (Todd 1975, Todd and Dodd 1985, O'Brien 1994) and National Diet and Nutrition Survey (Hinds and Gregory 1995). Revalidation should have been carried out before and after the study to verify consistency between examiners.

Whilst it was unfortunate that BASCD criteria were not used, it would have been necessary to modify them because this study used non-dental staff for data collection. The criteria used were based upon the BASCD survey criteria, although detail such as enamel-only lesions and lesions into dentine could not be introduced because of the limited knowledge of the examiners.

Due to time restraints previously mentioned (Section 2.1.2), the trainer was unable to attend a BASCD training and calibration course prior to the CIF dental study.

Future studies of the ALSPAC children may attract adequate funding to permit data collection by dentists and this is would provide data comparable to

BASCD surveys. However, it is possible that, with adequate training time and additional material, the non-dental staff could be trained to an even higher standard than that reached here.

Inevitably, the criteria used in this study would have to be altered, since the children will be in the mixed or permanent dentition at subsequent examination. If non-dental staff were employed, then it would be necessary to begin with basic dental identification before introducing the recognition of dental disease.

However, the author believes that similar standards of data collection can be achieved for future studies with careful planning to allow protracted training and calibration to take place.

9.2.1 Reproducibility of the trainer

Reproducibility of the trainer (Gold Standard) was within acceptable limits.

As one would expect, the trainer produced consistently high levels of agreement at each of the trainer-reproducibility studies (at 31-, 43- and 61-months). It is generally accepted that kappa should be ≥0.75 and in this study the values for identification of tooth condition were close to, or within this range. All variables produced good or better agreement, with the exception of the assessment of the lower median diastema. In the 31-month study, two of 31 cases differed and at 43-months, four of 33 cases differed.

Closer scrutiny of the results showed that due to the small number of children examined (around 30) and the sensitivity of the test, disagreement with only one case substantially reduced the value of kappa.

A weakness of the kappa statistic is that the value of kappa depends upon the proportion of subjects in each category. In the analysis, some variables produced 4x4 tables (Table 9.1). These gave higher kappa values than those variables that produced 2x2 tables (Table 9.2) even when the same number of cases differed for each variable.

Table 9.1: Example of 4x4 table for upper labial segment (U)

Upper labial segment – Initial examination	Upper labial segment – Repeat examination					
		C	K	Q	S	Total
	C		1			1
	K	1	13		1	15
	Q			1		1
	S		1		15	16
	Total	1	15	1	16	33

Kappa = 0.782 (Good agreement) - four cases differed

Table 9.2: Example of 2x2 table for lower median diastema (LM)

LM - Initial examination	Lower median diastema (LM) – Repeat examination			
		N	Y	Total
	N	28	1	29
	Y	3	1	4
	Total	31	2	33

Kappa = 0.275 (Fair agreement) – four cases differed

At 61-months, all variables produced good or better strength of agreement with the exception of three dental erosion variables for the depth of erosion of the palatal surfaces (52PD, 51PD and 62PD), which showed moderate strength of agreement.

Dental erosion is known to be difficult to assess. When the erosion variables were modified to record the presence of erosion rather than the depth and area of tooth affected, more consistent levels of agreement were produced. All variables produced good (or better) agreement ($\kappa \geq 0.6$), with the exception of the two variables for the upper left lateral incisor (52PD and 52PA), which produced moderate agreement.

9.2.2 Reproducibility of the examiners

All three of the examiner-reproducibility studies produced moderate or better strength of agreement for all variables.

Examiner-reproducibility produced good levels of agreement for all variables at 31-months ($\kappa \geq 0.606$). This can be attributed, in part, to the small amount of caries seen throughout the study and the absence of any active dental intervention such as restorations.

By the time the children were 43-months-old, they had greater experience of caries, restorations and extractions (Chapter 4). These factors may have influenced the findings of the non-dental examiners. Their training had involved using models, clinical photographs and extracted teeth.

It was not possible to teach these staff any diagnostic skills that would otherwise be acquired during a formalised dental training course. As a consequence, there were occasions when the examiners were unable or uncertain of the definition of a condition that they observed. Although they were able to add comments to the data collected and were asked to describe what they could see, it was not always possible to reliably interpret these comments.

Six examiners collected data at 43-months. Three of these examiners had collected data at 31-months, whereas three were new to the study. This change in staff may have had an effect on the reliability of the identification of the study variables. It was envisaged that staff who had collected data at 31-months would be able to recall the knowledge taught and acquired at that time.

At 61-months, the two examiners had previously collected data at 31- and 43-months. Once again, it was assumed that knowledge previously acquired had been retained and the training programme concentrated on the introduction of the 20 dental erosion variables, with a revision of criteria used at the previous clinics. If neither examiner was available then the trainer examined the children.

The examiner-reproducibility was carried out on the tooth condition data and analysis was repeated following modification, which recorded the presence of restorations and caries without determining the number of surfaces affected. The modification improved the level of agreement for the lower left second primary molar (75) from 0.277 (poor) to 0.477 (moderate). All other tooth variables remained close to their original kappa values or decreased in value. This would suggest that modification was not necessarily beneficial to analysis of these study variables. However, this modification was used in the main analysis in order to provide groups of data that were large enough to allow statistical analysis to be carried out.

Assessment of examiner-reproducibility for dental erosion was carried out in a similar way to the tooth condition data, with modification so that the presence of erosion was recorded rather than the extent. This improved the results for 18 of the 20 erosion variables, however those for the depth and area of the upper left central incisor (61LD and 61 LA) showed a marked decrease from complete agreement (κ=1.00) to poor agreement (κ=-0.015), although only two cases differed.

Little benefit was gained from the modification of the dental erosion variables, although no detrimental effects were observed. The increase in the kappa values for the variables was very small and the resulting kappa value for depth and area of the labial erosion of the upper left central incisor (61LD and 61LA) was poor (κ=-0.015) and outside 95% confidence intervals.

It was not possible to check the reproducibility between the examiners due to the limited time available at each clinic (Section 2.1.2) and also because the examiners were collecting data for other aspects of the ALSPAC study. It is possible that, although the trainer (Gold Standard) had a degree of disagreement with the examiners, the examiners may have had similar interpretations of the criteria amongst themselves. This could result in a common bias throughout the data, introduced by the examiners but not identified by the trainer. Further studies should make provision for the assessment of reproducibility between the examiners as well as re-calibration of the trainer and examiners throughout the study.

The comparison between each examiner and the trainer could have been carried out to see whether individual examiners had a bias in reproducibility. However, this would have been of limited benefit given the small numbers of cases repeated for each examiner. It would also have been difficult to execute since the reproducibility study was carried out during the 15-minute slots allocated to the dental observation at each clinic. No repeat visits were planned for the children and, since the examiners collected data for other parts of the study when not required for the dental study, then it was impractical to consider more repeat examinations than were already planned.

As the children got older they developed more dental caries and this introduced more permutations for the examiners to deal with in their decision-making. This bears similarities to the findings of Howat and Cannell (1979) who found that hygienists were less able to determine early enamel lesions than obvious cavitation. Kwan *et al.* (1996) found good reliability when auxiliaries collected dental data from 5-year-olds, but less so with 12-year-olds (Kwan and Prendergast 1998). Training dental auxiliaries to use survey criteria relies in part on previous knowledge gained during their professional training programmes. In the present study, the examiners had no knowledge of dentistry other than their personal experience and so the training programme attempted to introduce only the criteria required for the study. This produced its own limitations because when the examiners encountered something that had not been seen during training, they had to describe this in layman's terms, which the trainer interpreted at a later stage. This inevitably led to some data being discarded because when in doubt, the examiners chose not to define study variables.

It is most likely that fewer data would have been missing if dentists had examined the children. However, given the limitations of budget and manpower and time available for training, the results of the training and reproducibility studies were extremely encouraging and within acceptable limits. A future study should make provision for increased training time, more hands-on practice sessions and a review of reproducibility prior to the definitive data collection.

9.3 Dental caries

Not surprisingly, the caries experience of the study group increased as the children got older.

It is acknowledged that direct comparison with other survey data should be treated with caution. However, around 74% of the children were caries-free at 61-months. The remaining 26% had a mean of 2.8 teeth affected by caries, which is relatively high compared with the average for the whole group (0.7) and the WHO oral health goals for the year 2000 (Fédération Dentaire Internationale 1982). It is interesting to note that 19% of the group had untreated caries at 61-months and only 12% had received treatment, either as extractions or restorations. In 1993, the Child Dental Health Survey (O'Brien 1994) found that fewer 5-year-old children were caries-free (55%), but a similar proportion had received restorations (15%). The Camden study (Holt *et al.* 1996) reported 70% to be caries-free, which is similar to the findings of this study and to the recent data for Bristol, reported in the Child Dental Health Survey of 5-year-olds (O'Brien 1994) The proportion of children with caries at 31-months was understandably low since the teeth are relatively newly erupted and, whilst susceptible to dental caries, the disease may not have had time to manifest clinically. Whilst not substantiated within this study, Howat and Cannell (1979) found that early enamel lesions were difficult to identify by dental hygienists. Although the non-dental staff employed in the current study were asked to record only overt cavitation, it is possible that small lesions were not reported.

The treatment received by the children at 31- and 43-months was primarily dental extraction with no restorations recorded at 31-months. This could be due to the extent of the caries, limited co-operation of the child or poor attitude of the parents. Parents may have been unaware of the need for treatment or perhaps felt that the child was too young to attend the dentist, until the child experienced pain. Alternatively, the dentist may have decided that restorations were not clinically indicated or indeed, that the child was unable to co-operate well enough to allow effective delivery of dental care.

Holt *et al.* (1996) found that preschool children who had caries, had similar levels of disease, regardless of whether they had visited a dentist or not. This suggests that dental attendance has little or no impact on the level of caries experienced by the children. Since the children who had received care in this study had undergone tooth extractions, it may be that these children attended at an early age, due to symptoms rather than to increased dental awareness of the parents.

Poor dental attendance (Rogers *et al.* 1984, Watt and Sheiham 1999) and uptake of dental care amongst families in lower socio-economic groups have been highlighted (King *et al.* 1983, Carmichael 1985). Nevertheless, more children are being registered with dentists at a younger age (Whittle and Whittle 1995, McCabe and Kinirons 1995). Interestingly, despite early registration, the proportion of children experiencing dental pain and extraction has not reduced (Whittle and Whittle 1995).

Since the ALSPAC study group is representative of children and families around the United Kingdom, these children are also likely to have their first dental visit at a young age. If this is the case, then it is possible that caries experience will decrease and a greater proportion of children will receive restorative care, with a corresponding decrease in the amount of untreated caries. Data regarding the children's initial dental attendance and reported treatment were not available at the time of this study, however, this information was collected via questionnaires completed by the parents and will be available in due course.

Poor attendance has also been linked with unavailability of or inaccessibility to dental care (O'Mullane and Robinson 1977). In the ALSPAC study area, the structure and size of the Community Dental Service is constantly changing, with clinics in areas of lower socio-economic climate being closed down and general dental practitioners urged to provide routine care for children. In addition, following radical changes in the National Health Service (NHS) dental system, including the inception of capitation and continuing care payments, a proportion of general dental practitioners have limited resource for delivery of NHS treatment or have opted out of the NHS. Many of these practitioners still offer NHS care to children. However, since the parents may be unable or unwilling to pay private dental fees for their own treatment, their non-attendance may affect the children.

It has been shown that the oral habits of families are formative, since parents are role models for their children (Blinkhorn 1982, Paunio 1994, Mattila *et al.* 2000). Therefore, if parents do not, or can not, attend for their own dental care then this is likely to be the pattern of attendance for these children in the future (King *et al.* 1983). Inaccessibility to care could be due to families not having a car (Rogers *et al.* 1984). However, more mothers in the ALSPAC study group have access to private transport (84%) than those in the rest of Britain (76%) (ALSPAC Study Team 2000).

There is a wealth of evidence implementing social and dietary factors in the development of dental caries in preschool children (Silver 1992, Winter *et al.* 1971, Holt *et al.* 1982, 1988, 1996), although few studies have shown conclusive evidence of a guaranteed reduction in caries. Whilst dietary advice concerning the dangers of frequent consumption of sugars can be given, it is not necessarily acted upon. The most consistent evidence is that toothbrushing with fluoride toothpaste reduces caries levels within populations (Kay 1998). The ALSPAC study is not designed to improve health. The children do not attend because they are ill and no advice or intervention, dental or otherwise, is permitted (Appendix 1.1).

It is unfortunate that mothers were not asked about their own dietary habits. Since Blinkhorn (1982) suggested that children's habits were dependent on those of their parents, it would have been of interest to test the hypothesis here.

Socio-demographic factors were investigated in this group of children. These factors were used, since the *Registrar General's Classification of* Occupations, used in other studies, is outmoded and because the proportion of single-parent families and rates of unemployment would exclude valuable data. The social background of the children, based on the type of accommodation inhabited by the family, age and educational level of the mother, was associated with dental caries. Around 55% of mothers were educated to O-level standard and 17% lived in council or rented accommodation. A greater proportion of the children born to lower educated mothers and who lived in council or rented accommodation, had caries experience and untreated caries, although there was no perceived difference in the proportion of children receiving restorative care. Whilst no associations were seen between caries experience and the age of the mother, there was a tendency for more children born to older mothers to have experienced restorations than those born to younger mothers.

Mothers within lower socio-economic groups have poor knowledge of dental health (Blinkhorn 1982, Hood *et al.* 1998). Therefore, the education of families is paramount to improve the dental health of people within these groups and oral health programmes should target them. In the current study, information about the oral hygiene habits of mothers was not collected. Parents were asked about the frequency of toothbrushing and fluoride usage of the children, although these data were not used in this study. No record was made of the level of oral hygiene or the gingival condition of the children at examination or oral hygiene habits in this study.

Frequent consumption of non-milk extrinsic sugars is associated with caries. The consistency of food is also known to play an important part in the development of caries (Gustaffson *et al.* 1954). In this study, the frequency of consumption of foods known to be cariogenic, including chocolate, biscuits and crisps was compared with the presence of caries in the children. No account was made of the consistency, such as the type of chocolate bar, whether eaten at mealtimes, as a snack and whether teeth were brushed after the intake. These factors all have a bearing on the cariogenicity of each food and further investigation or questioning would have been appropriate. The data used to investigate the influence of foods and drinks in this study were collected via parent-completed questionnaires (Section 2.3), with parents being asked to recall the amount and frequency of food and drink over a period of one week or one month. This would be likely to introduce inaccuracies in reporting, since the data relies upon the parent recalling a child's intake, retrospectively, rather than completing a dietary diary at the time of completion of the questionnaire. The wording and content of the questions were requested by dieticians and nutritionists to gain information about general health and diet, rather than dental issues. This accounts for the limited information available to the author.

The variety of foods consumed by young children increases with age, particularly between 10- and 24-months of age (Rossow *et al.* 1990). This was the case in the current study. Many of the children were given sweet foods at a very young age. The diet expanded and consumption became more frequent as the child got older. By 24-months, around 90% of the children were eating biscuits, cereals, crisps, chocolate and other sweets. It was encouraging to see that around 90% of children were eating apples or other raw fruit. If the philosophy of others (Blinkhorn 1982, Paunio 1994, Mattila *et al.* 2000) apply to this group, then cariogenic foodstuffs given at a young age are likely to be eaten throughout life, unless oral health programmes educate families appropriately and successfully. The frequency of consumption of chocolate at 15-months was associated with the presence of caries at 43- and 61-months and addition of sugar to food was associated with the presence of caries at 43-months. This contradicts the work of Marques and Messer (1992) who found no association between caries and consumption of foodstuffs, including sugar, in preschool children. It is interesting to note that, although there was an association between the consumption of raw fruit and dental caries, this produced a negative effect, with those eating more fruit having less caries. It is likely that these children were given fruit rather than cariogenic alternatives.

The influence of dietary intake of children at 12 months and the presence of caries at 3 years has been investigated (Persson *et al.* 1985). Children born to mothers with a higher educational level had less sugar in the diet at 12 months and less caries at 3 years than children born to mothers who were lower educated and this is supported by others (Grytten *et al.* 1988, Wendt and Birkhed 1995). The

ALSPAC children born to mothers with a higher educational level had a trend towards less caries experience than those with a lower level, although these differences did not reach statistical significance. Therefore, early establishment of good dietary practice is necessary to achieve good oral health in preschool children and families thought to have a greater risk of developing caries should be targeted.

Valuable work has shown that the foods given to the ALSPAC children by their mothers are related to socio-demographic factors (North *et al.* 2000). The work showed that a diet of convenience foods was associated with younger, less educated mothers and although no association was demonstrated between maternal age and caries, the children of lower educated mothers had a greater proportion of caries in this study.

The change in caries levels between 43- and 61-months was substantial (12% to 26%) and although some children had received treatment, much of this had been as extraction, despite the placement of some restorations. These findings reinforce the importance of providing mothers with appropriate dental and dietary advice.

It is essential that the dental profession consider the long-term psychological, aesthetic and physical effects of both parental and 'supervised' neglect. As Curzon and Pollard (1997) said, dental caries is a disease, which should be treated. Doctors would not knowingly leave a disease untreated, particularly one which, in young children, might lead to an otherwise avoidable general anaesthetic with all its inherent health risks.

9.4 Dental erosion

The diagnosis and quantification of dental erosion is difficult. The calibration exercise for the Child Dental Health Survey in 1993 (O'Brien 1994) found this to be the area of greatest variation between dentists, particularly when the erosion was minimal and affected the enamel only.

The proportion of children with dental erosion on the palatal surfaces of the upper incisors in this study was 30%. Labial surfaces were affected in 4% and 2% had erosion of the occlusal surfaces of lower first molars. These figures are at odds with two other United Kingdom studies. The National Diet and Nutrition Survey (Hinds and Gregory 1995) found that 19% of children had erosion on the palatal surfaces of incisors and 10% on labial surfaces, whilst the Child Dental Health Survey (O'Brien 1994) found 52% of children had palatal erosion and 18% had labial erosion. Neither of these studies examined the condition of the molars.

In the current study, both lower molars and upper incisors had been affected by caries and those that could not be categorised were excluded from analysis. No information was available, which could determine whether teeth omitted from the survey had been restored or lost, as a direct result of dental erosion.

In this study, two non-dental health care professionals who had been trained by the third examiner, a qualified dentist, gathered the information. The training programme was based on that used in the previous United Kingdom surveys, with the same slides and accompanying explanation, courtesy of Dr June Nunn, although calibration and validation were not carried out before and after the study. The non-dental examiners had been asked to under score erosion whenever in doubt, since they would be unable to use diagnostic skills to determine between erosion and other forms of tooth wear such as attrition or abrasion. Therefore, it is likely that the extent of the erosion in this group is higher than actually recorded, echoing the concerns of others (Millward *et al.* 1994a, O'Sullivan *et al.* 1998).

The detrimental effect of misuse of acidogenic fruit drinks has been highlighted (Smith and Shaw 1987, Duggal and Curzon 1989) and whilst oral health and dietary advice may be given to parents, it is acknowledged that this is not always acted upon (Kay 1998).

In the current study, up to 53% of children consumed fruit drinks at 6-months and 77% at 24-months. Perhaps surprisingly, carbonated drinks had been given to 1% of the children at 6-months and to 50% by 24-months. As with foodstuffs, the range and frequency of fruit drink consumption increased as the diet expanded and children got older (Rossow *et al.* 1990).

There is evidence to suggest that the consumption of fruit drinks (excluding fruit juices) at 15-months is associated with the presence of erosion at 61-months. Certainly, at 15-months the median consumption of fruit drinks was higher in the group with erosion (4.0) than without (2.0). Since the frequency of consumption increased with age, it was surprising to find that consumption of these drinks at 24-months failed to reach significance. However, this may be due to the analysis of individual drink types rather than fruit drinks and juices as a whole, since the children may be drinking less of one drink, but more of another.

It may be beneficial to consider drinks in specific groups rather than individually, in a similar way to the analysis of food types reported by North *et al.* (2000).

Nevertheless, this research has shown that the frequency of intake of carbonated and non-carbonated drinks at 15- and 24-months is associated with the presence of erosion on the palatal surfaces of incisors.

Therefore, it is important to provide parents with advice about the inherent dangers of drinking acidic fruit drinks and eating citrus fruits to excess. Sipping these drinks should be avoided, since the longer the drink lasts, the longer the plaque pH will remain below the critical level causing dissolution of the enamel. Research shows that drinks consumed through a narrow straw placed at the back of the mouth avoid contact with the teeth and subsequently reduce the erosive potential of the drinks (Edwards *et al.* 1998). As the drink is quickly cleared from the mouth, there is less risk of a critical reduction in the plaque pH (Tahmassebi and Duggal 1997).

The recent innovation of low erosive fruit juices (Hughes *et al.* 1999) should contribute to a reduction in erosion, provided parents are given adequate and timely advice. The commercial name (Toothkind™) must surely encourage parents to consider this drink in preference to its original counterpart. Media coverage and commercial advertising can help to boost sales. A hard-hitting campaign could be the answer to promote drinks proven to be less erosive to the teeth. Certain drinks that do not benefit dental (or general) health are promoted in this way, such as fruit drinks with high sugar content and the ability to reduce plaque pH to critical levels.

It has been suggested elsewhere that dental erosion is not class-related (Millward *et al.* 1994b). However, socio-demographic factors used in this study suggest palatal erosion was more prevalent in children with younger mothers and who lived in council or rented accommodation, although of the children with erosion the majority lived in mortgaged or owned property. Given the profile of the ALSPAC children, this is not surprising (ALSPAC Study Team 2000), since a greater proportion of children lived in mortgaged or owned property.

9.5 Non-nutritive sucking habits

Studies have shown the prevalence of non-nutritive sucking habits to vary between 61% and 87% (Ravn 1974). However, materials and methods differed between studies and direct comparisons should be treated with caution.

In agreement with other studies (Modéer *et al.* 1982, Farsi and Salama 1997), the present study shows that dummy sucking is more prevalent than digit sucking. A digit or dummy was sucked by 60% of the children at some time between 15- and 36-months of age. At 15-months, 60% of children had a sucking habit, 38% sucked a dummy compared with 23% who sucked a digit and 2.8% of children sucked both At 36-months, dummies were still sucked by 18%, whilst 18% sucked a digit and 1.8% sucked both. Whilst these figures are similar to those of Larsson (1971), they differ to those reported in other studies. Cerny (1981) found that 20% of 3-year olds still had a sucking habit, whilst Wendt *et al.* (1992) reported the much higher figure of 59%.

Zadik *et al.* (1977) found that children who sucked a dummy were less likely to suck a digit and the results of the present study support this, suggesting that children choose one habit or the other and rarely both. Therefore it can be assumed that one habit will usually satisfy the sucking urge.

Non-nutritive sucking habits develop during the first few months of life reaching the highest level at around 12-months (Modéer *et al.* 1982). Whilst the digit habit remains fairly constant, possibly until 7 years of age, the dummy habit decreases until around 4 years of age, when the remaining dummy suckers are likely to stop as contact with other children increases. As shown in other studies, digits are not given up as easily as dummies, although fewer children tend to suck digits. Dummies can be taken away from the child to eradicate the habit. However, this may encourage a digit habit if the dummy is taken away before the child is willing or able to cease non-nutritive sucking (Larsson 1985).

Sucking habits are known to affect the developing occlusion in various ways. The disturbances recorded in this study bear similarities to those recorded elsewhere.

Unlike other studies, overjet, skeletal pattern and inclination of the incisors were not considered and so comparison of the apparent effect of sucking habits on the labial segment alignment is not possible. However, significant association was seen between a digit sucking habit and spaced upper labial segments at 43- and 61-months. The digit habit appeared to have little effect on the lower labial segment. Dummy sucking had significant effect on the upper labial segment at 61-months, but the trend was for the labial segment to have no spacing. There was some indication of increased spacing in the lower segment at 31- and 43-months, which may have been due to fanning of the lower incisors, as a result of proclination.

Prolonged sucking habits are associated with maxillary proclination (Svedmyr 1979). Since overjet was not recorded, explanation about the alignment of the upper segment is open to interpretation in this study.

As the incisors are influenced by the position of the digit, then the degree of proclination may differ for each incisor, resulting in uneven spacing. A dummy is placed in the centre of the mouth and the open bite formed is usually elliptical. This suggests that the incisors may move together so that, whilst all four may be proclined, any spacing is distal to the segment. Evidence suggests that prolonged digit sucking is associated with increased overjet (Fukuta *et al.* 1996, Farsi and Salama 1997). However, Ravn (1976) found that the majority of digit suckers did not have increased overjet, but if present then it was likely to be greater than 6 mm. It is unfortunate that this cannot be substantiated by this study.

Prolonged dummy sucking causes more profound effects on the anterior and posterior occlusion than digit sucking (Svedmyr 1979, Larsson 1994). However, because a dummy habit is usually given up earlier than a digit habit, the long term effects of digit sucking can be more damaging to the occlusion.

In the present study, dummy sucking had the most consistent and convincing effect on both the anterior and posterior occlusion at 31-, 43- and 61-

months and was associated with open bite and posterior crossbite in each case. These findings support the work of Svedmyr (1979) and Paunio *et al.* (1993b).

Digit sucking had an effect, but less so. The most noticeable effects were seen when a digit was being sucked persistently and particularly if sucked at 36-months. These habits were associated with open bite at 43- and 61-months and posterior crossbite at 61-months. There was an association between crossbite at 43-months and digit sucking at 36-months, but not with the persistent digit habit. Other workers have found an association between digit sucking and crossbite (Infante 1976). However, there is evidence that when the digit habit stops, whilst open bite may correct itself (Moore *et al.* 1972, Ravn 1976), the crossbite is not self-correcting (Infante 1976) and this is so for a prolonged dummy habit (Svedmyr 1979).

In this study, a larger proportion of children with crossbite were dummy suckers rather than digit suckers and this is similar to the findings of Modéer *et al.* (1982), but at odds with Svedmyr (1979). Non-suckers had lower prevalence of crossbite and this is in agreement with Øgaard *et al.* (1994). Approximately 12% of the children had crossbite and this figure remained the same throughout the study, which is in agreement with statements by Kutin and Hawes (1969) and Kisling and Krebs (1976).

Socio-demographic factors have been associated with sucking habits, as have certain aspects of dental health. In contrast to other reports (Calisti *et al.* 1960, Infante 1976), the dummy suckers in this study were more likely to be born to younger, lower educated mothers. However, in agreement with Larsson (1985) more boys than girls were dummy suckers. Parents tended to use the dummy to comfort children if they cried or were ill (North *et al.* 1999). Dummy sucking has been linked to poor oral hygiene (Paunio *et al.* 1993b). Unfortunately, the oral hygiene of the children in the current study was not assessed. Other work has implicated the use of sweetened comforters and poor feeding habits on the development of caries (Winter 1980, Silver 1992, Holt *et al.* 1996) and although sweetened comforters were not specifically highlighted here, no significant association was found between caries and dummy sucking.

9.6 Concluding remarks

This study has clearly shown potential for the employment of non-dental auxiliary staff to collect clinical dental data, following appropriate training.

Longitudinal data has shown trends in caries experience and the treatment received within this group. Further questionnaire data will become available throughout the ALSPAC study including information about dental attendances and treatment received.

The association between consumption of carbonated and non-carbonated fruit drinks on the presence of erosion on palatal surfaces was reported. Further data collection when the permanent dentition has fully erupted and modification of analysis may refine the findings of this study.

Non-nutritive sucking habits were shown to affect the developing dentition, particularly open bite and posterior crossbite. Although dummy sucking produced more noticeable effects, digit sucking also affected both anterior and *posterior occlusion*.

The ALSPAC study is a valuable resource of longitudinal information about the growth and development of 14000 children. Longitudinal studies are extremely hard to instigate and require a large amount of manpower and massive commitment on the part of the study participants and staff.

It is intended that the ALSPAC study should continue for the foreseeable future and it is essential that appropriate parties maintain the current level of input to such an historic undertaking.

Future work

Several aspects of this study would benefit from further investigation.

Data collected to date

Due to the large amount of data collected, the study has concentrated largely upon descriptive analyses. Using more complicated techniques, it would be possible to further investigate the interaction of social and dietary factors with the dental findings reported here.

Future Data

It is strongly recommended that the children be dentally examined at 12 years of age.

Collection of the data

In view of the encouraging results of using non-dental staff in the present study, it would be of great interest to determine whether their use was similarly successful when the children gained their permanent dentition.

Data collection by dentists would allow the use of BASCD criteria and as a consequence, direct comparison could be made with other surveys.

This information would be used to:

1. Observe changes in dental disease and occlusal development between 5 and 12 years of age.

2. Make comparisons between this group and the children examined in other surveys, including the Child Dental Health Surveys, which are carried out in the United Kingdom.

3. Assess the future development of dental disease in the permanent dentition.

4. Further assess the influence of dietary habits on the development of dental caries and erosion.

5. Observe the development of the permanent occlusion and investigate the long-term influence of past and present non-nutritive sucking habits. This should include the collection of retrospective data regarding dummy design to examine the effects of design on the development of the occlusion. Where ethically feasible, this investigation should be supported with radiographic evidence in order to assess the inclination of teeth and skeletal pattern.

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Appendix 1.1

Organisation of the Children in Focus clinics

Premises

At 4 months, clinics were held in rooms made available at Bristol & Weston Health Authority's Tyndall's Park Children's Centre. Availability of the premises restricted our clinics to Saturdays and two weekdays and therefore limited the number of children seen.

From the 8-month clinic onwards part of the Homeopathic Hospital's ground floor, which was vacant and in a relatively poor state of decoration was used. The South West Regional Health Authority, who then owned the building and the University of Bristol arranged some redecoration. The premises, though not ideal, provided a non-clinical setting and exclusive use of the rooms, which was invaluable in creating a relaxed and welcoming atmosphere.

Creating the atmosphere

A great deal of care had been taken to make coming to the clinic a positive experience for parents and children. Staff were selected who had a warm and understanding approach as well as the skills required for their role at the clinic. Initial and on-going training and supervision maintained the standards set. Plants, posters and mobiles decorated the rooms and were changed regularly, as were the toys which were available in the reception room. On arrival, the mother (father, grandparent or childminder) and child were offered refreshments. They were asked about their journey and the taxi or parking. Siblings who accompanied the study child were cared for by receptionists while the parent, or other carer, took the child around the clinic. At the end of the visit, the receptionist offered expenses or ordered a taxi and asked how they found the visit this time. Any comments were noted. Two receptionists were regularly on duty at each clinic and extra help was given by the other members of the team when needed. School holidays often meant that several siblings were left in the reception area and an extra receptionist was then required.

All letters, forms and questionnaires sent to mothers from the clinic were written in a friendly and sympathetic way and a similar approach was taken in telephone conversations. Every effort was made to accommodate the parents' wishes as to times and dates of appointments if those originally offered were inconvenient and understanding was shown when parents had difficulties. From 4 years onwards parents of children who had started school were sent a letter for the child's teacher asking for leave of absence for the visit.

Maintaining the cohort

This cohort of children attending the Children in Focus clinic was meticulously documented throughout the first years of life and was seen as a rare and valuable resource. It was considered essential for the research that as many as possible were retained in the study. The aim was to make each visit so enjoyable that they wanted to come back again and again.

Mothers (fathers or carers) brought their children to Children in Focus clinics voluntarily. The children were not ill and they did not get treatment. The child was brought to help with research that aims to make children healthier in the future. The only regular benefits to the child were that his/her vision was screened and defects were followed up and that parents were told if the child's haemoglobin was below 8g/dl, assuming that a blood sample was taken. At the 31 months clinic they were also told if the blood lead level was above 25 µg/dl and at 43 months if the child's hearing was 'below normal' (ceased to hear accurately a voice at above 35dBA) on that day. In each case the parent received a letter to take to their GP or health visitor.

The team of staff built up valuable experience in the day to day running of the clinics and in encouraging the continuing co-operation of parents and their children. These skills were vital to the success of Children in Focus and helped in planning the later Focus clinics.

Making the visit short

Smooth passage through the clinic and making the length of the visit short were priorities. Up to and including the 3- year clinic each child's visit was kept to within an hour and ten minutes wherever possible. This was achieved by having only four procedures at each stage and keeping each one within 15 minutes.

The exceptions to that rule were at 18 and 31 months. Because the Griffiths developmental test at 18 months took an average of 51 minutes per child, 4 testers operated at each clinic and took children in rotation. The length of stay was about two hours. Parents were warned in advance, apologies were given and invitations to the next clinic emphasised that this next visit would take little more than an hour. At 31 months, and subsequently when venepuncture was used, 20 minutes were allowed for each procedure since the blood takers had to see the child twice, first to obtain permission and to put on the anaesthetic cream and later to take the blood. At 49 months the WPSSI (the developmental test) again took 50-60 minutes and the length of the stay was about 1 hour 40 minutes. After the break in clinics, the visit at 61 months was longer to accommodate 7 different observations. It took about 2 $^3/_4$ hours.

Expenses and taxis

The invitation to the clinic explained that a taxi could be provided if parents did not have transport available and that expenses would be offered to cover fuel costs if they brought their own car, or fares if they came by bus or train. Those parents who agreed to come from out of the study area were offered £10 towards their travel costs. Parking was reserved for parents and other carers behind the Homeopathic Hospital and a temporary permit was sent in advance. The CIF clinic was in close contact with the taxi company and training was given to the drivers on the standard of service required. Any problems were followed up immediately with the company, so that a high standard could be maintained. Baby seats were carried on journeys to and from the clinic from the time that the children were 8 months old. Since the beginning of the 2-year clinics, booster seats were carried for siblings and later the study children to use.

Following up non-attenders

If a mother did not arrive for an appointment she received a telephone call or letter expressing concern that there may have been a problem and offering another appointment. Approximately 1.6% of those booked did not arrive and a further 3.7% were unable to attend because of illness, a new baby or a holiday, which took them past the age up to which we could see the children. Although this increased the costs, double bookings were only made in exceptional circumstances so that parents did not normally have to wait to be seen.

Presents

Each child was offered a small present at the end of every visit. These gifts were either donated by companies or provided at a discounted cost to the study.

Appendix 1.2

Numbers of children seen

Parents were invited to bring their children to the clinic at 4, 8, 12, 18, 25, 31, 37, 43, 49 and 61 months of age.

Mothers of 1023 babies came to the 4-month clinic and were invited again at 8 months, together with 16 who had been willing but unable to come at 4 months. A further 550 cases were invited at 8 months to increase the size of the cohort and of these 389 came to the 8 month clinic. Children of parents who attended, or were willing at attend at 4 and/or 8 months formed the Children in Focus cohort who were invited to subsequent clinics. Only those who died or whose parents refused further participation in Children in Focus or in the main study were deleted. No new children were added.

In all mothers of 2066 children were invited to the clinic. Of these 1432 children (69%) including 18 sets of twins were actually brought to at least one clinic. Unfortunately one baby who had been to the 4-month clinic, and another who had been to both the 4- and 8-month clinics, subsequently died.

Clinic	Date	Children invited	Children seen	% of those invited
4 months	6.10.92 - 3.4.93	1509	1023	68%
8 months	5.2.93 - 4.8.93	1589	1314	83%
12 months	8.6.93 - 4.12.93	1398	1241	89%
18 months	7.12.93 - 10.6.94	1341	1183	88%
25 months	5.7.94 -12.1.95	1322	1127	85%
31 months	14.1.95 - 6.7.95	1305	1135	87%
37 months	10.7.95 - 13.1.96	1226	1031	84%
43 months	16.1.96 - 6.7.96	1249	1065	85%
49 months	9.7.96 - 8.1.97	1268	1032	81%
61 months	NA	NA	994	NA

NA: Not available

Response variables

Whether invited and whether attended

	Not invited*	Invited and attended	Invited and refused	Invited did not attend	Invited did not respond	Invited unable this clinic
4m	557	1023	130	62	276	18
8m	1	1314	59	41	137	38
12m	-	1241	17	20	72	48
18m	32	1183	22	19	54	63
25m	31	1127	23	21	73	78
31m	40	1135	13	10	76	71
37m	45	1031	13	15	92	75
43m	44	1065	9	13	94	68
49m	21	1032	78	22	75	61
61m	NA	994	NA	NA	NA	NA

NA: Not available

Ages at attendance

The target ages for the children were:

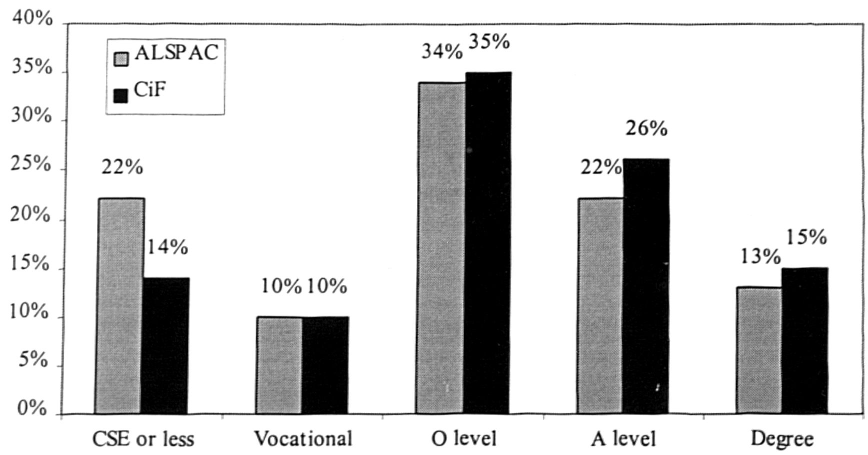
a) 3 months 3 weeks
b) 8 months
c) 12 months and 1 week
d) 18 months and 1 week
e) 25 months and thereafter at 6 month intervals until 49 months, and then at 61 months.

The study aimed to see children within a limited time of that ideal age and this 'window' of time varied with the needs of the tests at each clinic. Due to illness or family commitments, some children could not be seen within these limits. Rather than omitting them from the study at that time and possibly losing them from the cohort altogether, some were seen outside the recommended 'window'.

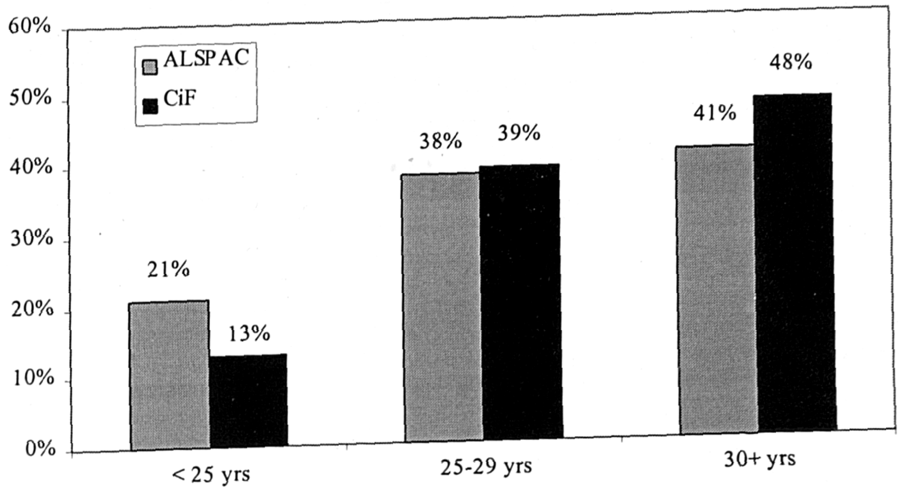
Bias

The mothers of the Children in Focus cohort at 18 months (i.e. those who had brought their children to either the 4 or 8 month clinic or both, and had not subsequently refused to participate) were compared for certain social variables with the rest of the ALSPAC cohort. There were significant differences in the mother's educational level and her age when the study child was born, but not in the number of children in the family (see below). This suggests that the group, which was invited but did not participate in the clinics, is non-random. In order to take account of this in cross-sectional analyses, it is possible to use appropriate weighting factors. For longitudinal analyses it is unlikely to be important.

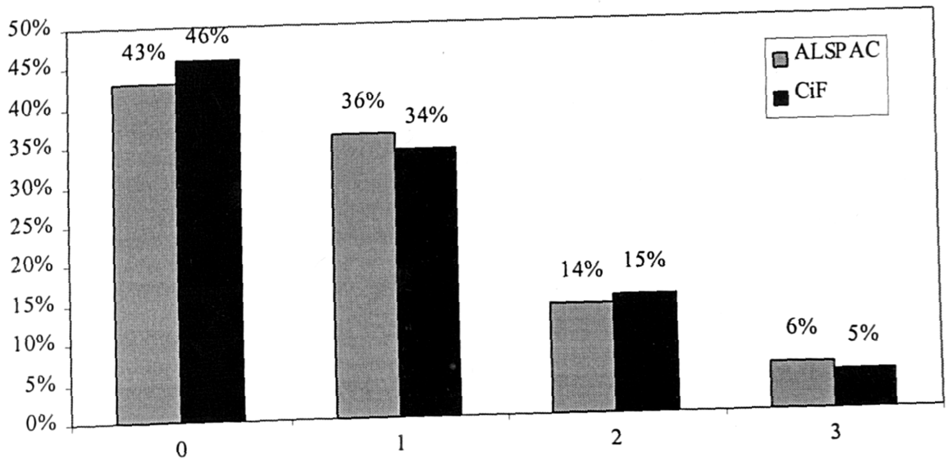
Mother's highest educational level



Maternal age group



Family size



Representative nature of sample

A number of studies have been undertaken to assess the representative nature of the ALSPAC sample who were completing questionnaires or attending the Children in Focus clinic with (a) the total Avon area population, and (b) the whole of Great Britain.

The population of parents and children living in the study area in 1970 were broadly similar to those of the rest of Great Britain. The 1991 census was used to compare the population of mothers with infants under 1 year of age resident in Avon with those in the whole of Britain. The results are shown below:

	Avon	Whole of Great Britain
Owner occupier	68.7%	63.4%
1+ person/room	26.0%	30.8%
Car in household	83.7%	75.6%
Married couple	71.7%	71.8%
Non-white mother	4.1%	7.6%

Thus the mothers of infants in Avon were slightly more likely than those in the rest of Britain to live in owner occupied accommodation, to have a car available to the household and to be less likely to have one or more persons per room and be non-white.

The comparison of the ALSPAC population completing questionnaires 8 months post-delivery with the whole eligible population is shown below:

	ALSPAC	Avon
Owner occupier	79.1%	68.7%
1+ person/room	33.5%	26.0%
Car in household	90.8%	83.7%
Married couple/family	79.4%	71.7%
Non-white mother	2.2%	4.1%

Thus, similar to all studies where a representative sample has been attempted, this study had a slight shortfall in the less affluent families (those living in rented accommodation, not having a car or being single or unmarried cohabiting). The study had a shortfall in ethnic minority mothers.

Appendix 1.3

Postnatal Self-Completion Questionnaires Relating to the Baby

C.1 My Young Baby Boy/Girl (4wk)
C.2 My Son/Daughter (6mth)
C.3 My Infant Son/Daughter (15mth)
C.4 Boy/Girl Toddler Questionnaire (18mth)
C.5 My Little Boy/Girl (24mth)
C.6 My Study Son/Daughter (30mth)
C.7 My Three-Year Old Boy/Girl (38mth)
C.8 My Son/Daughter's Health & Behaviour (42mth)
C.9 My Four-Year-Old Boy/Girl (54mth)
C.10 Development & Health of My Son/Daughter (57mth)

Sample Of Questionnaires
Each questionnaire contained around 30 pages of questions in a similar style to that shown below. Typically questionnaires were divided into many sections (e.g. A. You and your son , F. Feeding, H. Understanding and Talking, J. His growth) and each section could contain up to 70 questions (eg I.1-I.70 Temperament).

My Little Boy/Girl (24mth)

F9. Since he was 15 months old has he had:

	No	Yes	How often nowadays (put 00 if no longer happens) times a week
a) coca cola or pepsi			
b) other fizzy drink			
c) apple juice			
d) blackcurrant juice or rosehip syrup			
e) other fruit juice			
f) a little alcohol			
g) any other fruit drink (e.g. orange squash)			
h) herbal drink (please describe)			

F20. How often does he suck and dummy or his thumb or finger?

	a) dummy	b) thumb/finger
a) most of the time		
b) sometimes		
c) never		

Sample of questions in 36-month questionnaire – My 3 year old girl

E5. How many times nowadays does she eat:

	Never or rarely	Once in 2 weeks	1 - 3 times a week	4 – 7 times a week	More than once a day
a) Sausages, Burgers					
b) Pies, Pasties (pork pie, steak/meat pie etc.)					
c) Meat (beef, lamb, pork, ham, bacon etc.)					
d) Poultry (chicken, turkey etc)					
e) Liver, liver pate, kidney, heart					
f) Fish fingers					
g) White fish, not fish fingers (cod, haddock, plaice, etc)					
h) Other fish (pilchards, sardines, mackerel, tuna, herring, kippers, trout, salmon etc)					
i) Shellfish (prawns, crab, cockles, mussels etc)					
j) Eggs, quiche					
k) Cheese					
l) Pizza					
m) Chips					
n) Roast potatoes (cooked in fat)					
o) Boiled, mashed, jacket potatoes					
p) Rice (boiled, or fried)					
q) Pot Noodles, cook-in sauces, Ragu etc.					
r) Pasta (eg. spaghetti, lasagne)					
s) Crisps					
t) Fried foods (eg. fried fish, eggs, bacon, chops etc)					

E6. Does she eat the fat on meat?

Yes, all of it **Yes, some of it** **No** **Never eats meat**

E7. How many times nowadays does she eat:

	Never or rarely	Once in 2 weeks	1 - 3 times a week	4 – 7 times a week	More than once a day
a) Baked beans					
b) Peas, sweetcorn, broad beans					
c) Cabbage, brussel sprouts, kale and other green leafy vegetables					
d) Other green vegetables (cauliflower, runner beans, leeks etc)					
e) Carrots					
f) Other root vegetables (turnip, swede,parsnip etc)					
g) Salad (lettuce, tomato, cucumber etc)					
h) Pulses - dried peas, beans, lentils, chick peas, bean curd, tahini					
i) Nuts, nut roast					
j) Soya 'Meat', T.V.P., Vegeburgers					
k) Fresh fruit (apple, pear, banana, orange, bunch of grapes etc)					
l) Yoghurt, Fromage Frais, milk puddings, mousse					
m) Pudding (eg fruit pie, crumble, cheesecake, gateaux)					
n) Oat cereals (eg porridge, Ready Brek, muesli)					
o) Wholegrain or bran cereals (eg. All Bran, Bran Flakes, Weetabix, Wheatflakes, Fruit & Fibre)					
p) Other cereals (eg Corn- flakes,Rice Krispies, Frosties)					
q) Cakes or buns (fruit cake, flapjack, scone, custard tart, cream cake etc)					
r) Crispbreads (Ryvita, crackerbread etc)					
s) Biscuits (digestive, shortcake, Hob Nobs, Rich Tea, Nice, Marie)					
t) Chocolate biscuits, chocolate fingers, (Penguin, Club, Kit Kat etc)					
u) Chocolate bars (Mars, Twix, Wispa, Bounty, Creme Egg etc)					
v) Chocolate (dairy milk or plain, white chocolate, smarties etc)					
w) Sweets (cola bottles, penny mix-ups, chews, jelly sweets etc)					

E8. On days when she has sweets, how many individual sweets does she eat in that day? Count a chew or jelly sweet as one sweet.

1-2	3-5	6-10	11 and over

E9. On the day when she has chocolates or chocolate bars, how much does she eat (give as proportion of Mars bar, bag of buttons, etc)

Less than a quarter	About a quarter	About a half	About three-quarters	Whole	More than one	Never has chocolate

E10. How many times a week nowadays does she drink?

	Never or rarely	Once in 2 weeks	1 - 3 times a week	4 – 7 times a week	More than once a day
a) Fruit juice from a tin (including tomato juice)					
b) Pure fruit juice carton/ freshly squeezed					
c) Squash, fruit drink or Ribena					
d) Cola drinks e.g. Coca Cola, Pepsi etc.					
e) Other fizzy drinks e.g. lemonade					
f) Water on its own					
g) Milk on its own					
h) Flavoured milk/yoghurt drinks, ready made					
i) Flavoured milk drinks (not ready made) hot or cold					

E11. When she has soft drinks, how often are they low calorie, diet or reduced sugar drinks?

Usually	Sometimes	Not at all	Doesn't drink soft drinks

Appendix 1.4

Number of children examined by each examiner at each age (excluding repeat examinations for reproducibility)

	Examiners										
	Trainer	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**Total**
31-months	25	250	264	254	101	96	112				1102
43-months	3	195	91	145				230	183	216	1063
61-months	110	571	311								992

Appendix 2.1

FDI (Federation Dentaire Internationale) 2-digit tooth identification index

Each tooth is identified using 2 digits; the first identifies the **quadrant** and whether the tooth is **deciduous** or **permanent** and the second identifies the **tooth type**.

The four quadrants for the **deciduous** dentition of the mouth are identified as:

	Upper	Upper	
Right	5	6	Left
	8	7	
	Lower	Lower	

The teeth are then coded:

Tooth type	Identification Number
Central incisor	1
Lateral incisor	2
Canine	3
First molar	4
Second molar	5

Therefore, the 2-digit codes are:

	55	54	53	52	51	61	62	63	64	65
R										L
	85	84	83	82	81	71	72	73	74	75

Therefore, the individual code for each tooth is:

55	Upper right E (second molar)
54	Upper right D (first molar)
53	Upper right C (canine)
52	Upper right B (lateral incisor)
51	Upper right A (central incisor)
61	Upper left A (central incisor)
62	Upper left B (lateral incisor)
63	Upper left C (canine)
64	Upper left D (first molar)
65	Upper left E (second molar)

75	Lower left E (second molar)
74	Lower left D (first molar)
73	Lower left C (canine)
72	Lower left B (lateral incisor)
71	Lower left A (central incisor)
81	Lower right A (central incisor)
82	Lower right B (lateral incisor)
83	Lower right C (canine)
84	Lower right D (first molar)
85	Lower right E (second molar)

Appendix 2.2

Modified FDI index

In the early mixed dentition, the first permanent molars and the incisors erupt.
The quadrants were numbered as for the deciduous dentition, contrary to the official FDI index for permanent teeth.
The first permanent molars were identified using the tooth type code 6.
The permanent incisors were given the deciduous tooth code preceded by the word 'new'.

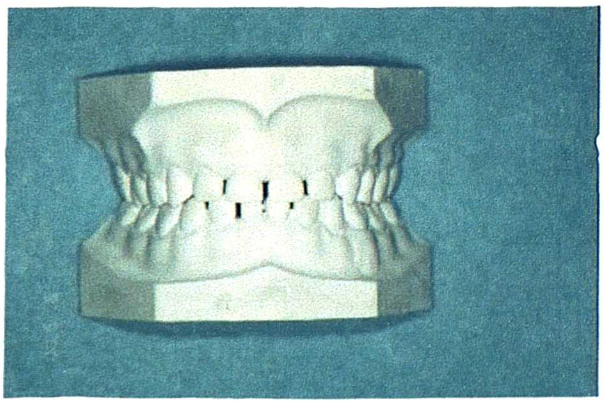
Therefore, the additional codes were:

56	Upper right 6 (first permanent molar)
66	Upper left 6 (first permanent molar)
76	Lower left 6 (first permanent molar)
86	Lower right 6 (first permanent molar)

New 51 Upper right 1 (permanent central incisor)
New 61 Upper left 1 (permanent central incisor)
New 71 Lower left 1 (permanent central incisor)
New 81 Lower right 1 (permanent central incisor)

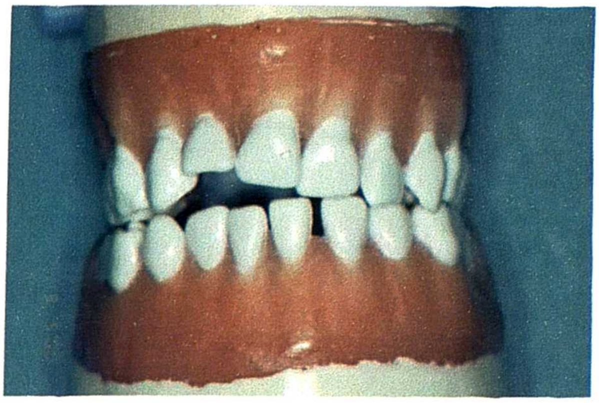
Appendix 2.3

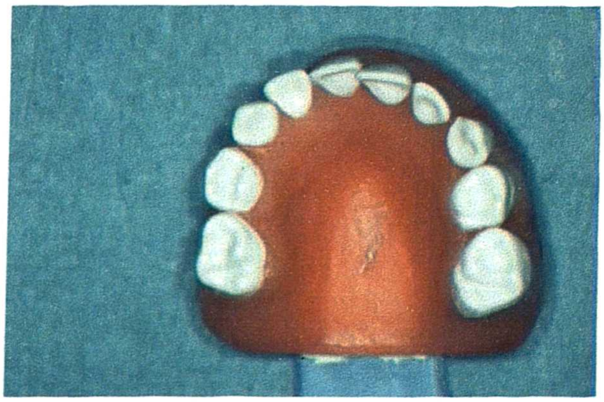
Plaster models of primary dentition issued at first training session

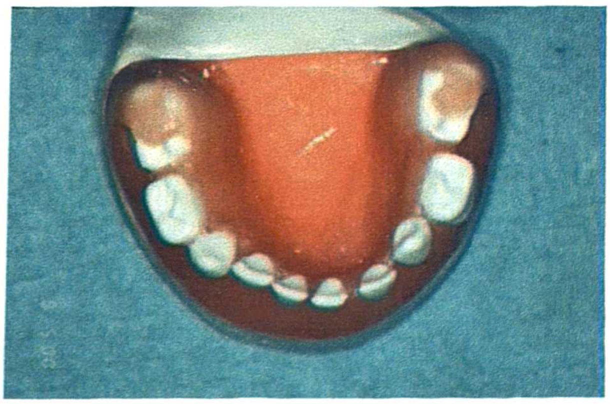


Appendix 2.4

One of seven articulated, acrylic models showing a sound dentition with variations in tooth number, arch form and occlusion (See **Appendix 2.6** for explanation of occlusal features)

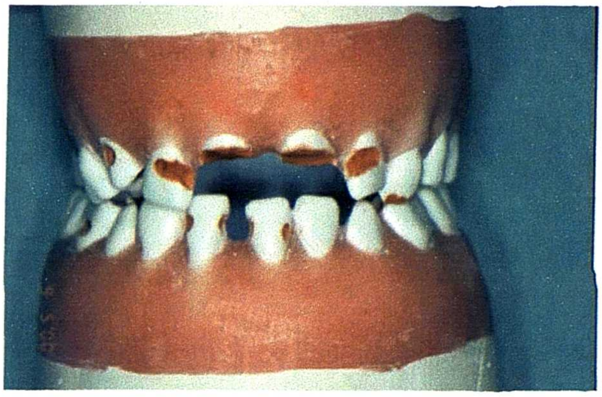


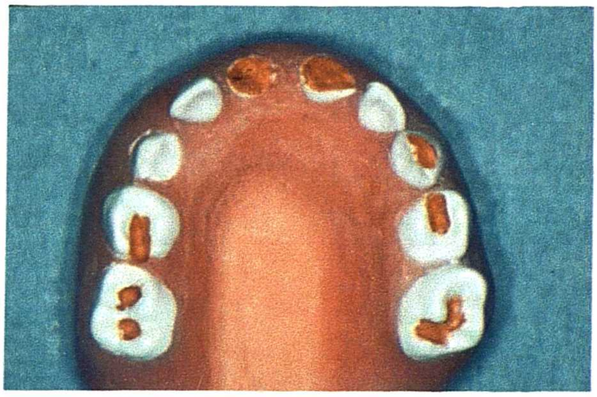


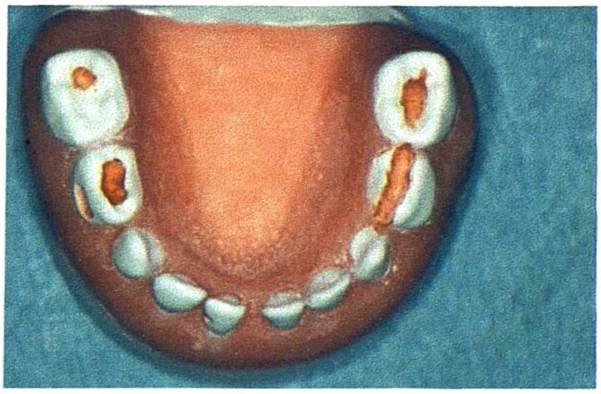


Appendix 2.5

One of ten articulated, acrylic models showing a carious dentition with variations in tooth number, arch form and occlusion (See **Appendix 2.6** for explanation of caries and occlusal features)







Appendix 2.6

CASE 1 (explanation of features seen in case shown in **Appendix 2.4**):
PLEASE COMPLETE THE FOLLOWING OBSERVATIONS:

1. **Circle the teeth present:**

55	54	53	52	51	|	61	62	63	64	65
85	84	83	82	81	|	71	72	73	74	75
P										P

NB **For extra teeth, use the prefix 9.**

2. **With teeth apart:**

ULS (U) → Well-aligned (K) / Crowded (C) / Spaced (S)

Q - unable to specify

Midline diastema? (M)

LLS (L) → Well-aligned (K) / Crowded (C) / Spaced (S)

Midline diastema? (M)

3. **With teeth together:**

i. <u>Front teeth</u>:

AOB (A) → N / Symmetrical (SYM) / R / L

Q - unable to specify

ii. <u>Back teeth</u>:

Crossbite (X) → R Y / N ; L Y / N

CASE 2 (explanation of features seen in case shown in **Appendix 2.5**):
PLEASE COMPLETE THE FOLLOWING OBSERVATIONS:

1. **Circle the teeth present:**

C1	**C2**	**C1**	**C1**	**C3**		**C1**	**C2**	**C1**	**C2**	**C1**
55	54	53	52	51	|	61	62	63	64	65
85	84	83	82	81	|	71	72	73	74	75
C1	**C2**			**C2**		**C2**			**C3**	**C1**

NB For extra teeth, use the prefix 9.

2. **With teeth apart:**

ULS (U) → Well-aligned (K) / Crowded (C) / Spaced (S)

(Q) **unable to specify**

Midline diastema? (M)

LLS (L) → Well-aligned (K) / Crowded (C) / Spaced (S)

Midline diastema? (M)

3. **With teeth together:**

i. Front teeth:

AOB (A) → **N** / Symmetrical **(SYM)** / **R** / **L**

(Q) **unable to specify**

ii. Back teeth:

Crossbite (X) → **R** Y / N ; **L** Y / N

Appendix 2.7

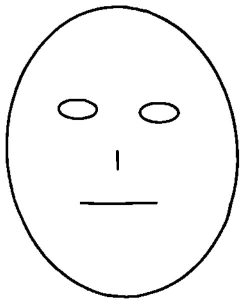
Deciduous dentition.

Guide to tooth identification.

At age 2yrs 7mths, a child will normally have all of their deciduous (baby or milk) teeth (**20** in total).

Looking at a face from in front

Right



Left

The mouth can be divided into FOUR corners or quadrants. Each quadrant is given a number:

	Upper	Upper	
Right	5	6	Left
	8	7	
	Lower	Lower	

The 20 teeth are divided between the four quadrants in the following way and each tooth is given a number as a code:

2 Incisors 1, 2
1 Canine3
2 Molars4, 5

These are arranged in the following way:

Molar	Molar	Canine	Incisor	Incisor	Incisor	Incisor	Canine	Molar	Molar
5	4	3	2	1	1	2	3	4	5

Each tooth is, therefore, coded with:

The **quadrant code** and the **tooth code**

Thus, around the mouth the teeth will be coded as follows:

	55	54	53	52	51	61	62	63	64	65	
R											L
	85	84	83	82	81	71	72	73	74	75	

Look at the models, familiarise yourself with the appearance and differing sizes of the teeth. ALWAYS START LOOKING AT THE CHILD (OR MODELS) FROM THE TOP RIGHT HAND QUADRANT. I.E. 55, 54 ETC.

NB Some teeth may be absent e.g. teeth which have been extracted (possibly upper 1's and 2's), may not have erupted yet (upper and lower 5's) or may be congenitally absent.

<u>Upper Labial Segment - CODE U</u>   52   51 | 61   62

If the four incisors are in an arc and are touching (i.e. Like soldiers standing in a row!) we say that they are well aligned CODE K. i.e. say CODE **UK**

If the 4 incisors have even spaces between them they are spaced CODE S i.e. say **US**

If there are no spaces between the teeth and they are overlapping each other, say **UC** (Crowded).

Between the two front incisors i.e. **51and 61,** there may be an exaggerated space - MEDIAN DIASTEMA. Say **UM.**

For example, **USM.**

<u>Lower Labial Segment - CODE L</u>   82   81 | 71   72

If the four incisors are in an arc and are touching (i.e. Like soldiers standing in a row!) we say that they are well aligned CODE K. i.e. say CODE **LK**

If the 4 incisors have even spaces between them they are spaced CODE S i.e. say **LS**

If there are no spaces between the teeth and they are overlapping each other, say **LC** (Crowded).

Between the two front incisors, 71 and 81, there may be an exaggerated space - MEDIAN DIASTEMA. Code - LM.

<u>Occlusion</u>

When the upper and lower teeth bite together (known as being **in occlusion**), usually the upper teeth fit around the lower with the outer surfaces (cusps) of the molar teeth overhanging the lower molars.

<u>Anterior open bite - CODE A</u>

If the upper and lower incisor teeth have a gap between them when the posterior (back) teeth are in occlusion, then this is called an anterior open bite (A) and you must categorise the relationship of upper and lower teeth as follows:

If there is NO space between the upper and lower anterior (front) teeth then the code used is N for NO - say **A - N**

The A may be oval or elliptical and is described as **symmetrical - CODE A - SYM.**

The A may be more prominent on the *child's* **right** or on the *child's* **left** - asymmetrical. (This may be induced by a right or left thumb habit.) You must categorise as follows:

Child's right - say **A - R**
Child's left - say **A - L**

Posterior Crossbite CODE X.

As already noted the upper teeth are normally arranged in a wider arch than the lowers so that the outer (buccal) cusps occlude outside the lowers.

Here, we look at the molars i.e. teeth coded numbers **4 & 5**

In some cases, the upper arch is narrowed so that the upper molar teeth lie inside the lowers and are said to be in **crossbite.**

The crossbite may only occur on one side - unilateral on the right or the left or both sides - bilateral.

To depict this we look first at the child's right say code **XR** and then **N** if there is no crossbite i.e. if the bite is normal - **XRN**

Say Y if there is a crossbite - **XRY**

IF IN DOUBT SAY Q, i.e. XRQ, XLQ BUT *PLEASE* TRY TO DEFINE.

Tongue The final observation is of the tongue. Ask the child to poke out his/ her tongue. If they can poke out the tongue so that you can see the tip, then say yes e.g., **T - Y**. If not then the child may have a tongue -tie say **T - N.**

There are a few other things to look out for as you move around the mouth:

Caries or dental decay.

This may appear brown, black or yellow. It should only be recorded if the tooth is cavitated. i.e. an obvious hole! The caries may affect one or more surfaces of the teeth and should be coded thus:

Discoloured anterior teeth.

Front teeth may be discoloured due to trauma (and also by decay)

This category is only looking at traumatic discoloration i.e., because the tooth is dead.

Therefore, the tooth should look intact, but **THE WHOLE TOOTH** may be discoloured brown or blue or dark yellow. **You will have the adjacent teeth for comparison.**

OTHER CODES

1. **Any variable that you are unable to categorise for any reason should be coded Q.**

2. **Extra teeth** **9** say this *when you see it.*

3. **Caries (C):**

Give quadrant and tooth code followed by:

- No decay - Tooth sound **No code**
- One surface decayed **C1**
- Two surfaces decayed **C2**
- More than 2 (gross caries) **C3**
- Gum boil **GB**

5. If there are any obvious restorations then change prefix to **F**:

- One surface restoration **F1**
- Two surface restoration **F2**
- More than 2 surfaces restored **F3**

Eg. 54 C2 GB, 75.

6. Discoloured front teeth - (D)

If yes:
Tooth code followed by **D**

Eg. 61 D

NB If all teeth appear discoloured - say **'ALL D' and describe discoloration eg. Green, brown etc** (parent will obviously be aware)

7. Tongue (T)

Ask child to poke tongue out and comment on whether they CAN poke it out or not!

Appendix 2.8

Erosion

When we look at the teeth for erosion we will examine the following teeth

	52 51 | 61 62	
84		**74**

We will look at the **labial** (front) and **palatal** (back) surfaces of **52 51 61 62** and the **occlusal** (biting) surfaces of **74 & 84.**

The surfaces will be assessed for loss of surface enamel characteristics and /or involvement of dentine (yellow) or pulp (pink, red, grey or 'hollow').

DO NOT SCORE THE INCISAL (BITING)EDGE.

IF IN DOUBT ALWAYS SCORE <u>LOW</u>.

Assess the **depth and area** of loss of tooth tissue for each surface using the following criteria:

Depth - (Code this first)

Code 0	Normal No tooth loss
Code 1	Enamel only - smooth rounded, shiny appearance
Code 2	Enamel and dentine loss - white 'halo' with yellow in centre
Code 3	Enamel & dentine loss into pulp - red, pink (alive), grey or hollow(dead)

Area - (Code this after depth)

Code 1	Less than 1/3 of surface area involved
Code 2	1/3 -2/3 of surface area involved
Code 3	More than 2/3 surface area involved.

Order of examination

Begin as previously although add new teeth if necessary.

Then begin with, for example:

52	labial 0 palatal scores 1 for depth, 2 for area
51	labial scores 1 for depth, 3 for area palatal scores 2 for depth, 3 for area
61	labial scores 1 for depth, 3 for area palatal scores 2 for depth, 3 for area
62	scores 9
74	scores 1 for depth, 2 for area
84	scores 0

Text to accompany clinical slides of dental erosion

Slide 1: Palatal view of 55 54 53 52 51 61 62 63 64 65

Can't really comment on labial (front) view of these teeth, but can comment on palatal view;

52 shows erosion on whole of palatal surface into dentine - you can see a white 'halo' affect plus yellow dentine of tooth 2 for depth, 3 for surface area

51 total involvement of palatal surface as 52 - 2 for depth and 3 for surface area

61 total involvement of palatal surface as 52 - 2 for depth and 3 for surface area

62 total involvement of palatal surface as 52 - 2 for depth and 3 for surface area

We will look at the occlusal (flat, biting surface) of 74 & 84 and so on this slide we will look at 54 & 64. The surface enamel (outer surface layer) is worn therefore:

54 would score 1 for depth (enamel only) - surface area scores 1 as less than 1/3 is affected.

64 depth - scores 1 - cupping on outer ridge of this tooth
area - more than 1/3 but less than 2/3 affected - therefore score is 2.

Slide 2: Palatal view: 53 52 51 61 62 63

52 & 62 - erosion on palatal surface to enamel only - depth scores 1
whole of surface affected therefore 3 for surface area

51 shows erosion into dentine and so would score 2 for depth but whole of surface area or at least 2/3 has been affected and so this would score 3 for surface area

61 erosion is marked and involves the pulp chamber - you can see pink on the slide and so would score 3 for depth (pulp involvement). The whole of the surface area is affected to approximately the same depth and so the surface area would score 3.

Slide 3: Palatal view in mixed dentition. The child has some new teeth which we will label as follows:

56 55 54 53 new 52, new 51, new 61, new 62, 63 64 65 66

Do note that the white patch on the 66 is a fissure sealant. You are unlikely to see these in CIF, however, if you do then comment on it at the time. (The parent will be aware that it is there!)

Looking at the erosion here now: Both 55 & 54 show erosion.

55 shows cupping into dentine - depth 2. The total surface area affeced is more than 1/3 but less than 2/3 and therefore scores 2 for area

54 shows extensive erosion into dentine - depth 2
majority of surface area affected therefore would score 3 for area

64 similar to 54- erosion into dentine - therefore would score 2 for depth
majority of surface area affected therefore would score 3 for area

65 likewise 2 for depth
total of surface area - more than 2/3 affected therefore 3 for area

Slide 4: Teeth present: 54 53 52 51 61 62 63 64

54 shows cupping of the occlusal surface just into dentine - area affected is more than 1/3 but less than 2/3 - therefore would score 2 for depth and 2 for area

52 palatal surface enamel only affected - so would score 1 for depth. **NB** - This is only a borderline case between 1 and 2 but remember that if in doubt always score LOW. We have scored 1 for depth but the whole of the surface area is affected so we would score 3 for area.

51 pulp chamber is involved and so would score 3 for depth. We are looking at the amount of surface are involved at this depth and as not all of the tooth surface is involved to this depth we would score the area as 2.

61 same as the 51 - the pulp is involved so scores 3 for depth, but not all of the surface area is involved at that depth (between 1/3 & 2/3) and so would score 2 for area.

62 is affected to dentine in the middle of the tooth and would score 2 for depth and 2 for area as more than 1/3 but less than 2/3 of the area is affected.

64 shows cupping on the occlusal surface into dentine and so would score 2 for depth. The total surface area when totalled is more than 1/3 but less than 2/3 and so would score 2 for area.

Slide 5: Labial view (front surface view) of 53 52 51 61 62 63

There is loss of surface enamel on particularly **51 and 61** . The surface is rounded, shiny and smooth and this is tooth surface loss of enamel only (not through to dentine) and would **score 1 for depth**, but the whole of the surface area is involved and would **score 3 for surface area.** You will also notice that the incisal or biting surface is worn down and you will remember that we are ignoring these surfaces as they may be worn due to attrition (grinding) rather than purely erosion.

Slide 6: Palatal view of 53 52 51 61 62 63:

52 shows some loss of enamel recording a depth of 1, the whole area is affected and so scores 3 for area.

51 tooth loss involving enamel and dentine - a depth of 2, but more than 2/3 of the tooth surface is affected and so the area score is 3.

61 tooth loss involving enamel and dentine - a depth of 2, but more than 2/3 of the tooth surface is affected and so the area score is 3.

62 shows some loss of enamel only and so scores a depth of 1, the majority of the tooth surface is affected and so scores 3 for area.

Slide 7: This shows palatal surfaces of 53 52 51 61 62 63:

Erosion can be seen on the palatal surfaces of 52 51 61 62

52 51 & 61 are all similar in that they have lost enamel and dentine and so would code a depth of 2. Less than 1/3 of the surface has been affected for each tooth and so the area code would be 1.

62 has tooth loss involving surface enamel only and would score 1 for depth and the majority of the surface has been affected by this to this depth and so would score 3 for surface area - we will ignore incisal wear.

Slide 8: Teeth present: 54 53 52 51 61 62 63 64:

54 cupping in enamel and also on the outside edge of the tooth - depth scores 1, but total of surface area is between 1/3 of the biting surface but less than 2/3 of the biting surface affected and so would score 2 for area.

Incisors are difficult to see in this case and remember that if in doubt we score LOW

52 would score 1 for depth - only in enamel and 3 for area - majority of tooth surface affected

51 enamel and dentine loss - 2 for depth - majority of tooth surface affected so 3 for area.

61 enamel and dentine loss - 2 for depth - majority of tooth surface affected so 3 for area

62 affected by caries and although you would have already coded this in the initial part of the observations, when you come to erosion, if you cannot define it then you give it a code 9 - therefore code 9 for depth and 9 for area.

64 shows early pitting or cupping on the outer and ridge but is only into enamel and so would score 1 for depth and 1 for area.

Slide 9: Labial view - particularly look at 51 & 61:

Wear is into enamel only- see the shiny, rounded, smooth surface and therefore both teeth would score 1 for depth but more than 2/3 of the tooth surface is affected and so both would score 3 for area.

Slide 10: Extracted 4:

With tooth being drier you can see the cupping on the biting surface more easily here. The wear is into dentine - depth of 2 and if you add the areas affected to that depth they add up to between 1/3 and 2/3 and so would score 2 for area.

Slide 11: Labial view of 56 55 54 53:

This slide is shown to demonstrate how excessive wear of the teeth can flatten the biting surfaces of the teeth completely. There is some cupping on the outside edges of the 55 & 54 and also you can see the 'rounding' of the edge from the biting surface to the cheek side of the tooth. This slide cannot be scored. The 53 also has some wear but is like incisal wear and may be due to attrition.

Slide 12: 54 53 52 51 61 62 63 64 6

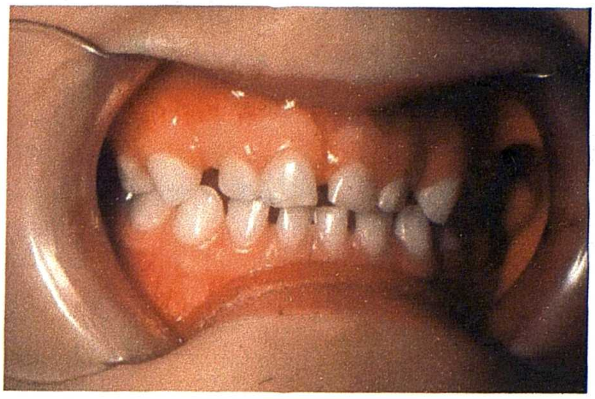
54 above the tooth on the gum there is an abscess which we code as G for gum boil and there is also some caries (C1) in this tooth.

52 51 61 62 have extensive caries. The surface is mushy rather than smooth and shiny as we have seen in the previous erosion slides. You are unable to give these a code for erosion and so should be coded as a 9 for depth and are.

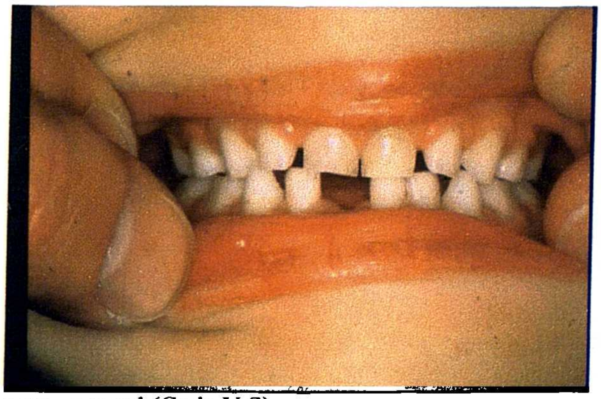
64 shows no evidence of erosion and should be coded as 0.

Appendix 2.9

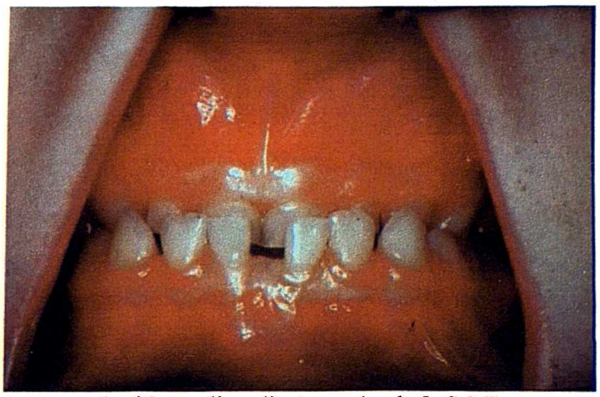
Sample of clinical photographs used to depict occlusal features



Upper labial segment - spaced with diastema (code U S M)
Lower labial segment - spaced (code L S)
Anterior occlusion - no open bite (code A N)



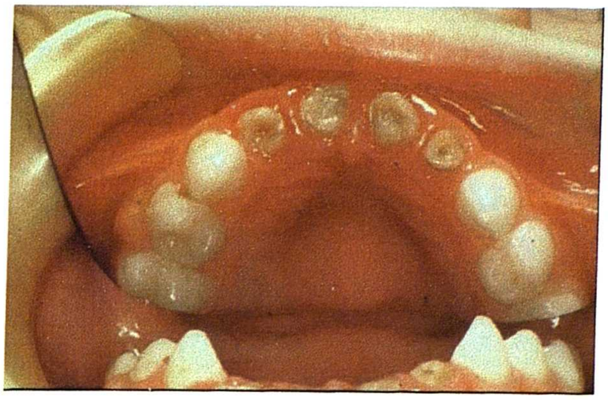
Upper labial segment - spaced (Code U S)
Lower labial segment - not determined (code L Q)



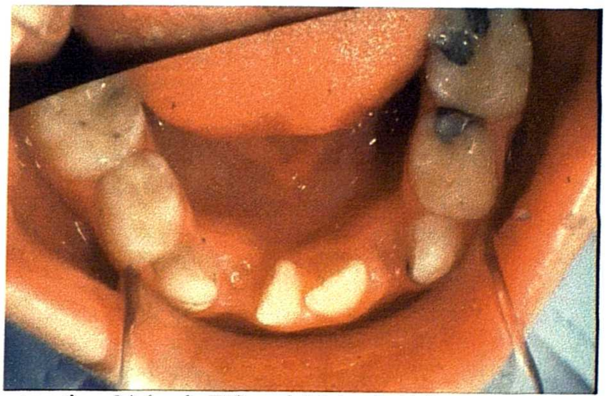
Lower labial segment - spaced with median diastema (code L S M)
Reverse overjet (code ROJ)

Appendix 2.10

Sample of clinical photographs used to depict caries and restorations



Caries affecting 52 51 61 62 (code C3)
54 53 63 64 sound (Code 0)



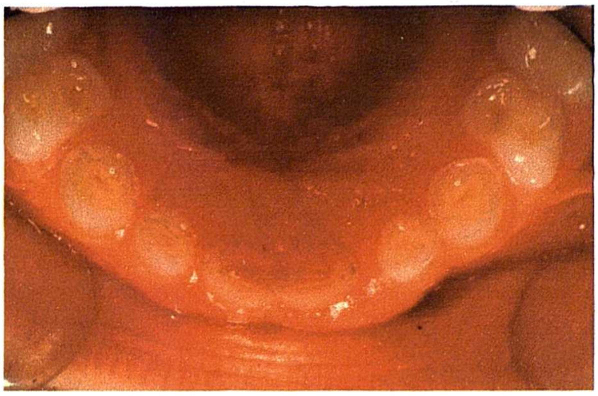
Glass ionomer restoration 84 (code F2) and 85 (code F1)
Amalgam (silver) restoration in 74 (code F2) and 75 (code F1)

Caries affecting buccal surfaces of 53 63 73 83 (code C1)
Caries affecting mesial surfaces 51 and 61 (code C1)
Crowding of lower labial segment (code LS)

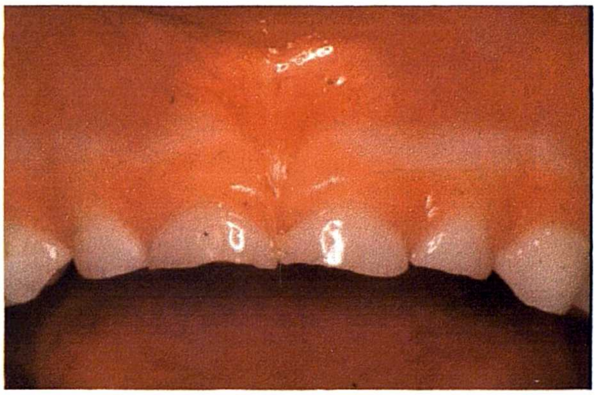
Appendix 2.11

Sample of slides depicting erosion (see **Appendix 2.8** for explanation of slides as numbered)

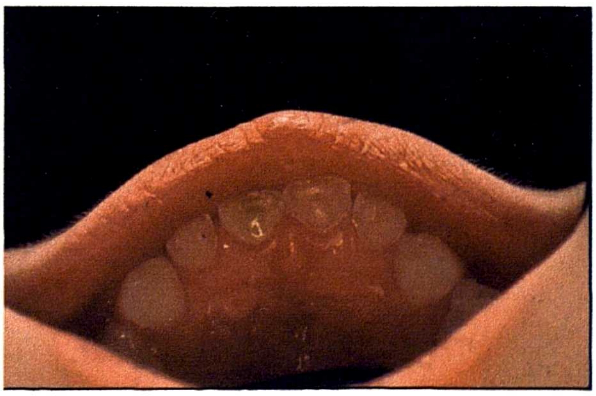
Slide 4



Slide 5



Slide 6



Appendix 3.1

Order of clinical observations at each clinic

31-month clinic – 12 appointments were available. The order of observations was strictly adhered to.

1. Day care - Inquiries were made about the daily care of the child including by whom and where the child was cared for each day.
2. EMLA provided the parent had given consent for a blood sample to be taken, EMLA topical anaesthetic cream was applied to the back of the hand or the fold of the elbow.
3. Vision was tested.
4. Tympanometry and a hearing test were carried out.
5. Dental observations were made.
6. Weight and height measurements were recorded.
7. Blood samples were taken

43-month clinic - 12 appointments were available. The order of observations was strictly adhered to.

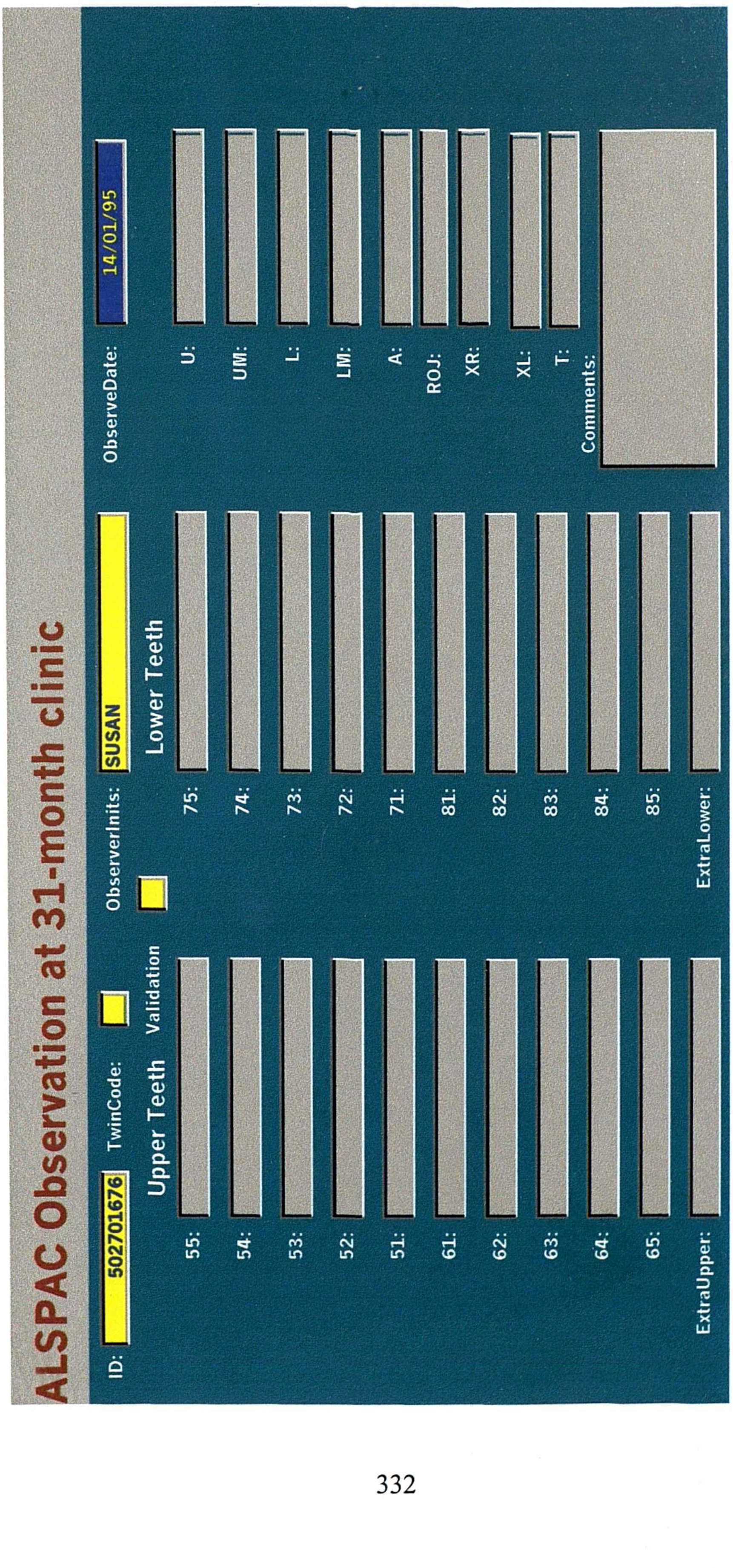
1. EMLA - to be applied if parental consent was given for blood to be taken.
2. Eyes - a vision test was carried out.
3. Play - cognitive development was observed.
4. Tympanometry testing and Dental observations (same observer for both)
5. Weight and body measurements were recorded.
6. Blood samples were taken.

61-month clinic – 16 appointments were available each day. The time that the child arrived at the clinic, determined the order in which the following observations were undertaken:

1. Application of EMLA (provided that parental consent for a blood sample was given.
2. Weight and body measurements.
3. Dental examinations.
4. Exercise.
5. Speech.
6. Allergy testing.
7. Hearing.
8. Blood samples where applicable.

Appendix 3.2

Sample of form used for data entry into database



ALSPAC Observation at 31-month clinic

ID: 502701676 TwinCode: ObserverInits: SUSAN ObserveDate: 14/01/95

Upper Teeth Validation Lower Teeth

55: 75: U:
54: 74: UM:
53: 73: L:
52: 72: LM:
51: 71: A:
61: 81: ROJ:
62: 82: XR:
63: 83: XL:
64: 84: T:
65: 85: Comments:
ExtraUpper: ExtraLower:

Appendix 3.3

PLEASE COMPLETE THE FOLLOWING OBSERVATIONS:

1. **Circle the teeth present:**

55	54	53	52	51	|	61	62	63	64	65
85	84	83	82	81	|	71	72	73	74	75

$U \rightarrow$ **K**

$U \rightarrow$ **C**

$U \rightarrow$ **S**

M ?

$L \rightarrow$ **K**

$L \rightarrow$ **C**

$L \rightarrow$ **S**

M?

$A \rightarrow$ **N**

$A \rightarrow$ **SYM**

$A \rightarrow$ **R**

$A \rightarrow$ **L**

ROJ?

$X \rightarrow$ **R** **Y / N**

$X \rightarrow$ **L** **Y / N**

T **Y / N**

Appendix 4

Trainer-reproducibility data at the 31-month clinic (31 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx Sig
55	31	1.000	0.000	5.568	<0.0001
54	31	Not Computed [a]	Not Computed	Not Computed	
53	31	Not Computed [a]	Not Computed	Not Computed	
52	31	Not Computed [a]	Not Computed	Not Computed	
51	31	Not Computed [a]	Not Computed	Not Computed	
61	31	1.000	0.000	5.568	<0.0001
62	31	Not Computed [a]	Not Computed	Not Computed	
63	31	Not Computed [a]	Not Computed	Not Computed	
64	31	Not Computed [a]	Not Computed	Not Computed	
65	31	0.652	0.321	3.871	<0.0001
Extra Upper	31	Not Computed [a]	Not Computed	Not Computed	
75	31	Not Computed [a]	Not Computed	Not Computed	
74	31	1.000	0.000	6.917	<0.0001
73	31	Not Computed [a]	Not Computed	Not Computed	
72	31	Not Computed [a]	Not Computed	Not Computed	
71	31	Not Computed [a]	Not Computed	Not Computed	
81	31	Not Computed [a]	Not Computed	Not Computed	
82	31	Not Computed [a]	Not Computed	Not Computed	
83	31	Not Computed [a]	Not Computed	Not Computed	
84	31	Not Computed [a]	Not Computed	Not Computed	
85	31	1.000	0.00	5.568	<0.0001
Extra Lower	31	Not Computed [a]	Not Computed	Not Computed	
U	31	0.934	0.064	5.214	<0.0001
UM	31	0.870	0.127	4.887	<0.0001
L	31	0.868	0.089	4.876	<0.0001
LM	31	0.475	0.306	3.106	0.002
A	31	1.000	0.000	7.114	<0.0001
ROJ	**NO**	**ROJs**	**RECORDED**		
XR	31	0.783	0.208	4.467	<0.0001
XL	31	Not Computed [a]	Not Computed	Not Computed	
T	31	0.652	0.321	3.871	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Trainer-reproducibility data at the 43-month clinic (33 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
55	33	1.000	0.000	7.335	<0.0001
54	32	1.000	0.000	5.657	<0.0001
53	33	Not Computed [a]	Not Computed	Not Computed	
52	33	0.476	0.316	3.493	<0.0001
51	32	1.000	0.000	7.225	<0.0001
61	33	1.000	0.000	8.838	<0.0001
62	32	1.000	0.000	5.657	<0.0001
63	33	Not Computed [a]	Not Computed	Not Computed	
64	32	1.000	0.000	5.657	<0.0001
65	33	1.000	0.000	7.335	<0.0001
Extra Upper	33	1.000	0.000	5.745	<0.0001
75	33	1.000	0.000	7.335	<0.0001
74	32	1.000	0.000	7.024	<0.0001
73	33	1.000	0.000	5.745	<0.0001
72	33	Not Computed [a]	Not Computed	Not Computed	
71	33	1.000	0.000	5.745	<0.0001
81	33	1.000	0.000	5.745	<0.0001
82	33	Not Computed [a]	Not Computed	Not Computed	
83	33	Not Computed [a]	Not Computed	Not Computed	
84	33	1.000	0.000	8.100	<0.0001
85	33	1.000	0.000	8.299	<0.0001
Extra Lower	33	Not Computed [a]	Not Computed	Not Computed	
U	33	0.782	0.098	5.279	<0.0001
UM	33	0.645	0.155	3.964	<0.0001
L	30	0.936	0.063	5.634	<0.0001
LM	33	0.275	0.257	1.693	0.090
A	33	1.000	0.000	7.187	<0.0001
ROJ	33	1.000	0.000	5.745	<0.0001
XR	33	0.653	0.321	3.998	<0.0001
XL	33	0.653	0.321	3.998	<0.0001
T	33	Not Computed [a]	Not Computed	Not Computed	

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Trainer-reproducibility data at the 61-month clinic – tooth variables (37 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
56	36	Not Computed [a]	Not Computed	Not Computed	
55	36	Not Computed [a]	Not Computed	Not Computed	
54	37	1.000	0.000	7.759	<0.0001
53	37	Not Computed [a]	Not Computed	Not Computed	
52	36	1.000	0.000	6.000	<0.0001
51	37	1.000	0.000	7.759	<0.0001
61	37	1.000	0.000	9.485	<0.0001
62	37	Not Computed [a]	Not Computed	Not Computed	
63	37	Not Computed [a]	Not Computed	Not Computed	
64	36	1.000	0.000	6.000	<0.0001
65	36	0.789	0.204	6.199	<0.0001
66	37	0.654	0.320	4.241	<0.0001
Extra Upper	37	Not Computed [a]	Not Computed	Not Computed	
76	36	0.654	0.320	4.182	<0.0001
75	36	0.899	0.100	7.749	<0.0001
74	37	1.000	0.000	8.550	<0.0001
73	37	1.000	0.000	6.083	<0.0001
72	37	Not Computed [a]	Not Computed	Not Computed	
71	37	0.846	0.151	6.366	<0.0001
81	37	0.877	0.120	6.733	<0.0001
82	37	1.000	0.00	6.083	<0.0001
83	37	Not Computed [a]	Not Computed	Not Computed	
84	36	0.789	0.204	6.199	<0.0001
85	36	0.789	0.204	6.199	<0.0001
86	37	1.000	0.000	6.083	<0.0001
Extra Lower	37	Not Computed [a]	Not Computed	Not Computed	
U	37	0.775	0.095	6.292	<0.0001
UM	37	0.720	0.130	5.106	<0.0001
L	35	0.712	0.106	5.385	<0.0001
LM	37	1.000	0.000	7.759	<0.0001
A	37	1.000	0.000	7.932	<0.0001
ROJ	37	1.000	0.000	7.759	<0.0001
XR	37	0.786	0.206	4.895	<0.0001
XL	37	1.000	0.000	6.083	<0.0001
T	37	1.000	0.000	6.083	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Trainer-reproducibility data at the 61-month clinic - Erosion variables (37 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
52 LD	37	1.000	0.000	6.083	<0.0001
52 LA	37	1.000	0.000	6.083	<0.0001
51 LD	37	0.654	0.320	4.241	<0.0001
51 LA	37	0.654	0.320	4.241	<0.0001
61 LD	37	0.786	0.206	4.895	<0.0001
61 LA	37	0.786	0.206	4.895	<0.0001
62 LD	37	Not Computed [a]	Not Computed	Not Computed	
62 LA	37	Not Computed [a]	Not Computed	Not Computed	
52 PD	35	0.367	0.288	2.846	0.004
52 PA	37	0.636	0.195	5.399	<0.0001
51 PD	37	0.589	0.127	5.419	<0.0001
51 PA	37	0.649	0.126	6.085	<0.0001
61 PD	37	0.672	0.118	6.299	<0.0001
61 PA	37	0.727	0.114	6.917	<0.0001
62 PD	37	0.515	0.184	4.194	<0.0001
62 PA	37	0.635	0.190	5.021	<0.0001
74 OD	37	1.000	0.000	6.083	<0.0001
74 OA	37	1.000	0.000	6.083	<0.0001
84 OD	37	0.641	0.231	4.176	<0.0001
84 OA	37	0.641	0.231	4.176	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Trainer-reproducibility data at the 61-month clinic - Modified erosion (37 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
52 LD	36	Not Computed [a]	Not Computed	Not Computed	
52 LA	36	Not Computed [a]	Not Computed	Not Computed	
51 LD	35	Not Computed [a]	Not Computed	Not Computed	
51 LA	35	Not Computed [a]	Not Computed	Not Computed	
61 LD	34	Not Computed [a]	Not Computed	Not Computed	
61 LA	34	Not Computed [a]	Not Computed	Not Computed	
62 LD	37	Not Computed [a]	Not Computed	Not Computed	
62 LA	37	Not Computed [a]	Not Computed	Not Computed	
52 PD	36	0.526	0.239	3.198	0.001
52 PA	36	0.526	0.239	3.198	0.001
51 PD	35	0.615	0.153	3.742	<0.0001
51 PA	35	0.615	0.153	3.742	<0.0001
61 PD	34	0.612	0.154	3.669	<0.0001
61 PA	34	0.612	0.154	3.669	<0.0001
62 PD	37	0.626	0.192	4.107	<0.0001
62 PA	37	0.626	0.192	4.107	<0.0001
74 OD	34	Not Computed [a]	Not Computed	Not Computed	
74 OA	34	Not Computed [a]	Not Computed	Not Computed	
84 OD	33	Not Computed [a]	Not Computed	Not Computed	
84 OA	33	Not Computed [a]	Not Computed	Not Computed	

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data at the 31-month clinic (164 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
55	164	1.00	0.000	15.928	<0.0001
54	164	1.00	0.000	12.806	<0.0001
53	164	1.00	0.000	16.229	<0.0001
52	164	1.00	0.000	12.806	<0.0001
51	164	0.798	0.198	13.228	<0.0001
61	164	0.798	0.198	13.228	<0.0001
62	164	Not Computed [a]	Not Computed	Not Computed	
63	164	1.00	0.000	12.806	<0.0001
64	164	Not Computed [a]	Not Computed	Not Computed	
65	164	0.897	0.035	14.314	<0.0001
Extra Upper	164	1.00	0.000	12.806	<0.0001
75	164	0.957	0.025	15.951	<0.0001
74	164	Not Computed [a]	Not Computed	Not Computed	
73	164	1.00	0.000	12.806	<0.0001
72	164	Not Computed [a]	Not Computed	Not Computed	
71	164	1.00	0.000	16.229	<0.0001
81	164	Not Computed [a]	Not Computed	Not Computed	
82	164	Not Computed [a]	Not Computed	Not Computed	
83	164	1.00	0.000	15.725	<0.0001
84	164	Not Computed [a]	Not Computed	Not Computed	
85	163	0.902	0.036	15.078	<0.0001
Extra Lower	164	Not Computed [a]	Not Computed	Not Computed	
U	164	0.923	0.031	12.778	<0.0001
UM	164	0.887	0.045	11.763	<0.0001
L	163	0.859	0.037	13.313	<0.0001
LM	164	1.00	0.000	12.806	<0.0001
A	164	0.951	0.028	15.338	<0.0001
ROJ	164	0.745	0.174	12.122	<0.0001
XR	162	0.606	0.147	7.779	<0.0001
XL	164	0.784	0.093	10.123	<0.0001
T	164	1.00	0.000	15.151	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data at the 43-month clinic (196 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
55	196	0.326	0.250	6.156	<0.0001
54	192	Not Computed [a]	Not Computed	Not Computed	
53	196	Not Computed [a]	Not Computed	Not Computed	
52	194	0.798	0.197	14.386	<0.0001
51	195	0.764	0.132	15.289	<0.0001
61	195	0.606	0.162	11.156	<0.0001
62	196	Not Computed [a]	Not Computed	Not Computed	
63	196	Not Computed [a]	Not Computed	Not Computed	
64	193	Not Computed [a]	Not Computed	Not Computed	
65	193	1.000	0.000	13.892	<0.0001
Extra Upper	196	Not Computed [a]	Not Computed	Not Computed	
75	194	0.661	0.183	11.666	<0.0001
74	190	0.664	0.315	9.721	<0.0001
73	196	Not Computed [a]	Not Computed	Not Computed	
72	194	1.000	0.000	13.928	<0.0001
71	194	1.000	0.000	13.928	<0.0001
81	196	1.000	0.000	14.000	<0.0001
82	196	1.000	0.000	14.000	<0.0001
83	196	Not Computed [a]	Not Computed	Not Computed	
84	196	Not Computed [a]	Not Computed	Not Computed	
85	194	0.323	0.174	6.292	<0.0001
Extra Lower	196	Not Computed [a]	Not Computed	Not Computed	
U	196	0.482	0.055	8.107	<0.0001
UM	196	0.668	0.066	10.211	<0.0001
L	196	0.647	0.047	11.666	<0.0001
LM	196	0.739	0.086	11.919	<0.0001
A	196	0.724	0.057	11.854	<0.0001
ROJ	196	0.745	0.174	10.427	<0.0001
XR	195	0.558	0.124	8.079	<0.0001
XL	192	0.676	0.115	9.381	<0.0001
T	194	1.000	0.000	13.928	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data at the 61-month clinic – tooth variables (67 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
56	66	0.660	0.317	5.700	<0.0001
55	66	0.407	0.200	4.505	<0.0001
54	66	1.000	0.000	8.124	<0.0001
53	67	Not Computed [a]	Not Computed	Not Computed	
52	67	Not Computed [a]	Not Computed	Not Computed	
51	66	1.000	0.000	8.124	<0.0001
61	65	1.000	0.000	8.062	<0.0001
62	66	Not Computed [a]	Not Computed	Not Computed	
63	67	Not Computed [a]	Not Computed	Not Computed	
64	66	1.000	0.000	10.324	<0.0001
65	65	0.882	0.116	8.412	<0.0001
66	67	1.000	0.000	8.185	<0.0001
Extra Upper	67	Not Computed [a]	Not Computed	Not Computed	
76	67	0.793	0.201	6.632	<0.0001
75	65	-0.024	0.018	-0.222	0.825
74	64	1.000	0.000	8.000	<0.0001
73	67	Not Computed [a]	Not Computed	Not Computed	
72	67	Not Computed [a]	Not Computed	Not Computed	
71	67	1.000	0.000	8.185	<0.0001
81	67	1.000	0.000	11.377	<0.0001
82	67	Not Computed [a]	Not Computed	Not Computed	
83	67	Not Computed [a]	Not Computed	Not Computed	
84	64	1.000	0.000	8.000	<0.0001
85	67	0.793	0.201	6.632	<0.0001
86	66	1.000	0.000	8.124	<0.0001
Extra Lower	67	Not Computed [a]	Not Computed	Not Computed	
U	67	0.529	0.088	5.941	<0.0001
UM	67	0.756	0.102	6.383	<0.0001
L	64	0.582	0.085	6.229	<0.0001
LM	67	0.573	0.187	5.188	<0.0001
A	66	0.817	0.126	6.635	<0.0001
ROJ	67	1.000	0.000	8.185	<0.0001
XR	67	0.634	0.169	5.189	<0.0001
XL	67	0.917	0.125	6.805	<0.0001
T	67	Not Computed [a]	Not Computed	Not Computed	

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data at the 61-month clinic - Modified tooth variables (67 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
56	66	0.660	0.317	5.700	<0.0001
55	66	0.548	0.232	4.503	<0.0001
54	66	1.000	0.000	8.124	<0.0001
53	67	Not Computed [a]	Not Computed	Not Computed	
52	67	Not Computed [a]	Not Computed	Not Computed	
51	64	Not Computed [a]	Not Computed	Not Computed	
61	67	0.794	0.200	8.456	<0.0001
62	67	1.000	0.000	8.185	<0.0001
63	67	Not Computed [a]	Not Computed	Not Computed	
64	67	0.794	0.200	8.456	<0.0001
65	65	0.881	0.118	7.152	<0.0001
66	67	1.000	0.000	8.185	<0.0001
Extra Upper	67	Not Computed [a]	Not Computed	Not Computed	
76	67	0.793	0.201	6.632	<0.0001
75	67	0.477	0.223	4.872	<0.0001
74	67	0.655	0.229	6.605	<0.0001
73	67	Not Computed [a]	Not Computed	Not Computed	
72	67	Not Computed [a]	Not Computed	Not Computed	
71	67	1.000	0.000	8.185	<0.0001
81	67	1.000	0.000	11.377	<0.0001
82	67	Not Computed [a]	Not Computed	Not Computed	
83	67	Not Computed [a]	Not Computed	Not Computed	
84	64	1.000	0.000	8.000	<0.0001
85	67	0.793	0.201	6.632	<0.0001
86	66	1.000	0.000	8.124	<0.0001
Extra Lower	67	Not Computed [a]	Not Computed	Not Computed	

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data at the 61-month clinic - Erosion variables (67cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
52 LD	67	Not Computed [a]	Not Computed	Not Computed	
52 LA	67	Not Computed [a]	Not Computed	Not Computed	
51 LD	67	0.660	0.317	5.700	<0.0001
51 LA	67	0.660	0.317	5.700	<0.0001
61 LD	65	1.000	0.000	8.062	<0.0001
61 LA	65	1.000	0.000	8.062	<0.0001
62 LD	67	Not Computed [a]	Not Computed	Not Computed	
62 LA	67	Not Computed [a]	Not Computed	Not Computed	
52 PD	66	0.415	0.144	4.658	<0.0001
52 PA	66	0.440	0.145	4.658	<0.0001
51 PD	64	0.237	0.117	2.579	0.010
51 PA	67	0.281	0.107	3.302	0.001
61 PD	67	0.285	0.100	3.540	<0.0001
61 PA	67	0.308	0.107	3.582	<0.0001
62 PD	67	0.357	0.139	3.929	<0.0001
62 PA	67	0.296	0.129	3.017	0.003
74 OD	66	0.377	0.283	3.134	0.002
74 OA	66	0.377	0.283	3.134	0.002
84 OD	65	0.792	0.202	6.530	<0.0001
84 OA	65	0.792	0.202	6.530	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data at the 61-month clinic - Modified erosion variables (67 cases)

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
52 LD	67	Not Computed [a]	Not Computed	Not Computed	
52 LA	67	Not Computed [a]	Not Computed	Not Computed	
51 LD	65	Not Computed [a]	Not Computed	Not Computed	
51 LA	65	Not Computed [a]	Not Computed	Not Computed	
61 LD	66	-0.015	.011	-.125	0.901
61 LA	66	-0.015	.011	-.125	0.901
62 LD	67	Not Computed [a]	Not Computed	Not Computed	
62 LA	67	Not Computed [a]	Not Computed	Not Computed	
52 PD	66	0.449	0.153	3.711	<0.0001
52 PA	66	0.449	0.153	3.711	<0.0001
51 PD	65	0.340	0.131	2.780	0.005
51 PA	65	0.340	0.131	2.780	0.005
61 PD	66	0.390	0.126	3.174	0.002
61 PA	66	0.390	0.126	3.174	0.002
62 PD	67	0.385	0.147	3.285	0.001
62 PA	67	0.385	0.147	3.285	0.001
74 OD	63	Not Computed [a]	Not Computed	Not Computed	
74 OA	63	Not Computed [a]	Not Computed	Not Computed	
84 OD	63	Not Computed [a]	Not Computed	Not Computed	
84 OA	63	Not Computed [a]	Not Computed	Not Computed	

a Statistics not computed as value of variable is a constant

b Not assuming the null hypothesis

c Using the asymptotic standard error assuming the null hypothesis

Examiners-reproducibility data - caries experience at the 31-, 43- and 61-month clinics - Modified tooth variables

Variable	No. of valid cases	Measurement of agreement: Kappa	Asymptotic Standard error [b]	Approx T [c]	Approx sig
dmft31	164	0.827	0.12	10.755	<0.0001
dt31	164	0.744	0.174	9.858	<0.0001
mt31	164	1.00	0.00	12.806	<0.0001
ft31	164	Not Computed [a]	Not Computed	Not Computed	
mft31	164	1.00	0.00	12.806	<0.0001
dmft43	196	0.669	0.082	9.537	<0.0001
dt43	196	0.506	0.11	7.28	<0.0001
mt43	196	1.00	0.00	14.00	<0.0001
ft43	196	0.659	0.184	9.285	<0.0001
mft43	196	0.849	0.086	11.902	<0.0001
dmft61	67	0.634	0.126	5.25	<0.0001
dt61	67	0.674	0.123	5.552	<0.0001
mt61	67	1.00	0.00	8.185	<0.0001
ft61	67	0.489	0.306	4.65	<0.0001
mft61	67	0.653	0.227	5.698	<0.0001

[a] Statistics not computed as value of variable is a constant
[b] Not assuming the null hypothesis
[c] Using the asymptotic standard error assuming the null hypothesis

Appendix 5.1

Comparison between number of children with discoloured teeth at the 31- and 43-month clinics

n=867 (100.0%)	No discoloration at 43-m 854 (98.5%)	Discoloured at 43-m 13 (1.5%)	χ^2	p value
No discoloration at 31-m 860 (99.2%)	849 98.7%	11 1.3%	35	0.004+
Discoloured at 31-m 7 (0.8%)	5 71.4%	2 28.6%		

+ Fisher's exact test

Comparison between proportion of children with discoloured teeth at the 43- and 61-month clinics

n=867 100.0%	No discoloration at 61-m 844 (97.3%)	Discoloured at 61-m 23 (2.7%)	χ^2	p value
No discoloration at 43-m 854 (98.5%)	838 98.1%	16 1.9%	134	<0.0001+
Discoloured at 43-m 13 (1.5%)	6 46.2%	7 53.8%		

+ Fisher's exact test

Comparison between proportion of children with discoloured teeth at the 31- and 61-month clinics

n=867 (100.0%)	No discoloration at 61-m 844 (97.3%)	Discoloured at 61-m 23 (2.7%)	χ^2	p value
No discoloration at 31-m 860 (99.2%)	838 97.4%	22 2.6%	4	0.172+
Discoloured at 31-m 7 (0.8%)	6 85.7%	1 14.3%		

+ Fisher's exact test

Proportion of children with tongue-tie at 31-months by proportion of children with tongue-tie at 43-months

n=750 (100.0%)	No tongue-tie at 43-months 747 (99.6%)	Tongue tie at 43-months 3 (0.4%)	χ^2	p value
No tongue-tie at 31-months 746 (99.5%)	744 99.6%	2 66.7%	61	0.016+*
Tongue tie at 31-months 4 (0.5%)	3 0.4%	1 33.3%		

* p<0.05 + Fisher's exact test

Proportion of children with tongue-tie at 43-months by proportion of children with tongue-tie at 61-months

n=750 (100.0%)	No tongue-tie at 61-months 744 (99.2%)	Tongue tie at 61-months 6 (0.8%)	χ^2	p value
No tongue-tie at 43-months 747 (99.6%)	743 99.9%	4 66.7%	165	<0.0001+
Tongue tie at 43-months 3 (0.4%)	1 0.1%	2 33.3%		

+ Fisher's exact test

Appendix 5.2

Pattern of extraction of 24 cases at 61-months where dmft considers canines and molars only

Case	Pattern of extraction	Value of mt at 61-months (canines and molars only)
1	55 54 64 65 85 84 74 75	8
2	54 53 63 64 84 74	6 (52 51 61 62 also extracted)
3	54 64 85 84 74 75	6
4	54 64 85 84 74	5
5	55 65 85 74 75	5
6	55 65 85 84 75	5
7	55 65 85 75	4
8	54 64 84 74	4
9	54 64 84 74	4
10	55 65 85 75	4
11	55 65 85 75	4
12	55 65 85 75	4
13	55 65 85 75	4
14	65 84 74 75	4
15	55 65 85 75	4
16	55 84 74	3
17	 85 84 75	3
18	 84 74	2
19	54 64	2
20	 85 75	2
21	54 64	2
22	 75	1
23	55	1
24	 85	1

Appendix 5.3

Proportion of children with untreated caries (dt) at the 31-month clinic (dt31>0) by proportion of children with untreated caries (dt) at the 43-month clinic (dt43>0)

n=793 (100.0%)	dt43=0 703 (88.7%)	dt43>0 90 (11.3%)	χ^2	p value
dt31=0 777 (98.0%)	696 75.4%	81 10.4%	33	<0.0001+
dt31>0 16 (2.0%)	7 43.8%	9 56.3%		

+ Fisher's exact test

Proportion of children with untreated caries (dt) at the 43-month clinic (dt43>0) by proportion of children with untreated caries (dt) at the 61-month clinic (dt61>0)

n=793 (100.0%)	dt61=0 639 (80.6%)	dt61>0 154 (19.4%)	χ^2	p value
dt43=0 703 (88.7%)	599 85.2%	104 14.8%	85	<0.0001
dt43>0 90 (11.3%)	40 44.4%	50 55.6%		

Proportion of children with untreated caries (dt) at the 31-month clinic (dt31>0) by proportion of children with untreated caries (dt) at the 61-month clinic (dt61>0)

n=793 (100.0%)	dt61=0 639 (80.6%)	dt61>0 154 (19.4%)	χ^2	p value
dt31=0 777 (98.0%)	630 81.1%	147 18.9%	6	0.022+
dt31>0 16 (2.0%)	9 56.3%	7 43.8%		

+ Fisher's exact test

Proportion of children with missing teeth (mt) at the 31-month clinic (mt31>0) by proportion of children with missing teeth (mt) at the 43-month clinic (mt43>0)

n=793 (100.0%)	mt43=0 779 (98.2%)	mt43>0 14 (1.8%)	χ^2	p value
mt31=0 787 (99.2%)	778 98.9%	9 1.1%	232	<0.0001+
mt31>0 6 (0.8%)	1 16.7%	5 83.3%		

+ Fisher's exact test

Proportion of children with missing teeth (mt) at the 43-month clinic (mt43>0) by proportion of children with missing teeth (mt) at the 61-month clinic (mt61>0)

n=793 (100.0%)	mt61=0 736 (92.8%)	mt61>0 57 (7.2%)	χ^2	p value
mt43=0 779 (98.2%)	736 94.5%	43 5.5%	184	<0.0001+
mt43>0 14 (1.8%)		14 100%		

+ Fisher's exact test

Proportion of children with missing teeth (mt) at the 31-month clinic (mt31>0) by proportion of children with missing teeth (mt) at the 61-month clinic (mt61>0)

n=793 (100.0%)	mt61=0 736 (92.8%)	mt61>0 57 (7.2%)	χ^2	p value
mt31=0 787 (99.2%)	735 93.4%	52 6.6%	53	<0.0001+
mt31>0 6 (0.8%)	1 16.7%	5 83.3%		

+ Fisher's exact test

Proportion of children with restored teeth (ft) at the 31-month clinic (ft31>0) by proportion of children with restored teeth (ft) at the 43-month clinic (ft43>0)

n=793 (100.0%)	ft43=0 780 (98.4%)	ft43>0 13 (1.6%)	χ^2	p value
ft31=0 793 (100.0%)	780 98.4%	13 1.6%	*	*
ft31>0 0 (0.0%)	0 0.0%	0 0.0%		

* Not computed as ft 31 is a constant

Proportion of children with restored teeth (ft) at the 43-month clinic (ft43>0) by proportion of children with restored teeth (ft) at the 61-month clinic (ft61>0)

n=793 (100.0%)	ft61=0 745 (93.9%)	ft61>0 48 (6.1%)	χ^2	p value
ft43=0 780 (98.4%)	739 94.7%	41 5.3%	53	<0.0001+
ft43>0 13 (1.6%)	6 46.2%	7 53.8%		

+ Fisher's exact test

Proportion of children with restored teeth (ft) at the 31-month clinic (ft31>0) by proportion of children with restored teeth (ft) at the 61-month clinic (ft61>0)

n=793 (100.0%)	ft61=0 745 (93.9%)	ft61>0 48 (6.1%)	χ^2	p value
ft31=0 793 (100.0%)	745 93.9%	48 6.1%	*	*
ft31>0 0 (0.0%)	0 0.0%	0 0.0%		

* Not computed as ft 31 is a constant

Proportion of children with evidence of treatment received (mft) at the 31-month clinic (mft31>0) by proportion of children with evidence of treatment received (mft) at the 43-month clinic (mft43>0)

n=793 (100.0%)	mft43=0 766 (96.6%)	mft43>0 27 (3.4%)	χ^2	p value
mft31=0 787 (99.2%)	765 97.2%	22 2.8%	117	<0.0001+
mft31>0 6 (0.8%)	1 16.7%	5 83.3%		

+ Fisher's exact test

Proportion of children with evidence of treatment received (mft) at the 43-month clinic (mft43>0) by proportion of children with evidence of treatment received (mft) at the 61-month clinic (mft61>0)

n=793 (100.0%)	mft61=0 695 (87.6%)	mft61>0 98 (12.4%)	χ^2	p value
mft43=0 766 (96.6%)	689 89.9%	77 10.1%	110	<0.0001+
mft43>0 27 (3.4%)	6 22.2%	21 77.8%		

+ Fisher's exact test

Proportion of children with evidence of treatment received (mft) at the 31-month clinic (mft31>0) by proportion of children with evidence of treatment received (mft) at the 61-month clinic (mft61>0)

n=793 (100.0%)	mft61=0 695 (87.6%)	mft61>0 98 (12.4%)	χ^2	p value
mft31=0 787 (99.2%)	694 88.2%	93 11.8%	28	<0.0001+
mft31>0 6 (0.8%)	1 16.7%	5 83.3%		

+ Fisher's exact test

Appendix 6

Mean frequency and standard deviation of weekly consumption of specified foods at 6-months by caries experience at 31-months

Food type at 6-m	dmft at 31-m	n	Mean	SD
Biscuits	No caries	822	0.51	1.43
	Caries present	17	1.24	2.49
Plain rusks	No caries	803	2.01	2.52
	Caries present	17	2.00	1.94
Sweetened rusks	No caries	814	0.61	1.60
	Caries present	18	1.06	1.92
Other cereals	No caries	810	4.49	2.95
	Caries present	17	5.00	2.55
Raw fruit	No caries	816	1.25	2.04
	Caries present	18	1.00	2.28
Chocolate	No caries	806	0.34	0.86
	Caries present	17	1.00	1.87
Sweets	No caries	827	0.02	0.24
	Caries present	18	0.00	0.00
Crisps	No caries	825	0.02	0.21
	Caries present	18	0.00	0.00

Mean frequency and standard deviation of weekly consumption of specified foods at 15-months by caries experience at 31-months

Food type at 15-m	dmft at 31-m	n	Mean	SD
Biscuits	No caries	735	5.77	3.19
	Caries present	17	6.41	2.55
Rusks	No caries	436	1.02	1.88
	Caries present	8	0.25	0.71
Raw apple	No caries	633	2.71	1.99
	Caries present	15	2.80	1.70
Other raw fruit	No caries	728	4.75	2.79
	Caries present	19	4.37	2.09
Chocolate	No caries	618	2.57	1.76
	Caries present	16	2.88	1.63
Sweets	No caries	211	2.12	1.92
	Caries present	11	1.55	0.52
Crisps	No caries	480	2.22	1.68
	Caries present	10	2.20	1.40
Sugar added to food	No caries	201	4.12	2.75
	Caries present	10	5.30	1.49

Mean frequency and standard deviation of weekly consumption of specified foods at 24-months by caries experience at 31-months

Food type at 24-m	dmft at 31-m	n	Mean	SD
Biscuits	No caries	710	5.56	2.78
	Caries present	19	4.88	2.75
Cereals	No caries	709	6.03	2.18
	Caries present	18	4.97	2.52
Raw apple	No caries	674	2.96	1.92
	Caries present	14	2.55	2.06
Other raw fruit	No caries	704	4.27	2.47
	Caries present	15	4.12	2.65
Chocolate	No caries	669	2.48	1.74
	Caries present	13	1.69	1.01
Sweets	No caries	550	2.38	1.74
	Caries present	10	3.17	2.16
Crisps	No caries	697	2.72	2.72
	Caries present	15	2.85	2.85
Sugar added to food	No caries	250	3.4	2.98
	Caries present	11	4.15	2.46

Mean frequency and standard deviation of weekly consumption of specified foods at 6-months by caries experience at 43-months

Food type at 6-m	dmft at 43-m	n	Mean	SD
Biscuits	No caries	726	0.48	1.37
	Caries present	113	0.78	1.94
Plain rusks	No caries	710	2.03	2.52
	Caries present	110	1.94	2.39
Sweetened rusks	No caries	719	0.58	1.56
	Caries present	113	0.86	1.89
Other cereals	No caries	716	4.49	2.95
	Caries present	111	4.56	2.92
Raw fruit	No caries	721	1.28	2.07
	Caries present	113	1.07	1.89
Chocolate	No caries	711	0.34	0.88
	Caries present	112	0.45	1.00
Sweets	No caries	731	0.01	0.17
	Caries present	114	0.04	0.47
Crisps	No caries	729	0.02	0.19
	Caries present	114	0.03	0.28

Mean frequency and standard deviation of weekly consumption of specified foods at 6-months by caries experience at 43-months

Food type	dmft at 43-m	n	Mean	SD
Biscuits	No caries	652	5.72	3.21
	Caries present	100	6.17	2.94
Rusks	No caries	395	0.99	1.88
	Caries present	49	1.12	1.76
Raw apple	No caries	554	2.65	1.95
	Caries present	94	3.07	2.17
Other raw fruit	No caries	644	4.71	2.73
	Caries present	103	4.96	3.03
Chocolate	No caries	548	2.49	1.73
	Caries present	86	3.14	1.85
Sweets	No caries	186	2.08	1.94
	Caries present	36	2.17	1.52
Crisps	No caries	424	2.17	1.67
	Caries present	66	2.53	1.65
Sugar added to food	No caries	182	3.98	2.76
	Caries present	29	5.45	2.03

Mean frequency and standard deviation of weekly consumption of specified foods at 24-months by caries experience at 43-months

Food type at 24-m	dmft at 43-m	n	Mean	SD
Biscuits	No caries	622	5.58	2.78
	Caries present	107	5.37	2.78
Cereals	No caries	626	6.04	2.11
	Caries present	101	5.77	2.66
Raw apple	No caries	589	2.97	1.92
	Caries present	99	2.88	1.96
Other raw fruit	No caries	619	4.30	2.52
	Caries present	100	4.07	2.15
Chocolate	No caries	589	2.45	1.74
	Caries present	93	2.53	1.65
Sweets	No caries	470	2.33	1.70
	Caries present	90	2.74	1.95
Crisps	No caries	610	2.69	1.84
	Caries present	102	2.90	1.96
Sugar added to food	No caries	223	3.32	2.99
	Caries present	37	4.12	2.76

Mean frequency and standard deviation of weekly consumption of specified foods at 6-months by caries experience at 61-months

Food type at 6-m	dmft at 61-m	n	Mean	SD
Biscuits	No caries	613	0.51	1.44
	Caries present	226	0.54	1.53
Plain rusks	No caries	602	2.06	2.03
	Caries present	218	1.88	1.87
Sweetened rusks	No caries	608	0.62	1.62
	Caries present	224	0.62	1.59
Other cereals	No caries	607	4.54	2.94
	Caries present	220	4.38	2.93
Raw fruit	No caries	611	1.30	2.07
	Caries present	223	1.11	1.99
Chocolate	No caries	600	0.30	0.84
	Caries present	223	0.50	1.02
Sweets	No caries	618	0.02	0.18
	Caries present	227	0.03	0.34
Crisps	No caries	615	0.02	0.20
	Caries present	228	0.02	0.22

Mean frequency and standard deviation of weekly consumption of specified foods at 15-months by caries experience at 61-months

Food type at 15-m	dmft at 61-m	n	Mean	SD
Biscuits	No caries	560	5.72	3.30
	Caries present	192	5.95	2.81
Rusks	No caries	339	0.99	1.88
	Caries present	105	1.09	1.82
Raw apple	No caries	477	2.66	2.03
	Caries present	171	2.85	1.87
Other raw fruit	No caries	555	4.78	2.88
	Caries present	192	4.64	2.44
Chocolate	No caries	458	2.46	1.72
	Caries present	176	2.88	1.84
Sweets	No caries	158	1.97	1.51
	Caries present	64	2.39	2.57
Crisps	No caries	361	2.19	1.69
	Caries present	129	2.31	1.62
Sugar added to food	No caries	146	4.12	2.85
	Caries present	65	4.32	2.40

Mean frequency and standard deviation of weekly consumption of specified foods at 24-months by caries experience at 61-months

Food type at 24-m	dmft at 61-m	n	Mean	SD
Biscuits	No caries	537	5.52	2.64
	Caries present	192	5.60	3.14
Cereals	No caries	539	6.11	2.07
	Caries present	188	5.66	2.47
Raw apple	No caries	499	3.05	1.96
	Caries present	189	2.72	1.80
Other raw fruit	No caries	538	4.42	2.57
	Caries present	181	3.82	2.11
Chocolate	No caries	506	2.41	1.74
	Caries present	176	2.61	1.69
Sweets	No caries	400	2.32	1.70
	Caries present	160	2.58	1.86
Crisps	No caries	520	2.66	1.83
	Caries present	192	2.88	1.91
Sugar added to food	No caries	184	3.46	2.90
	Caries present	76	3.35	3.14

Appendix 7

Mean frequency and standard deviation of weekly consumption of specified drinks at 6-months by any evidence of erosion at 61-months

Drinks at 6-m	Any erosion	n	Mean	SD
Cola	No	500	0.004	0.063
	Yes	264	0.008	0.087
Other carbonated drinks	No	501	0.004	0.063
	Yes	264	0.008	0.087
Apple juice	No	493	0.63	1.67
	Yes	259	0.79	2.04
Blackcurrant or rosehip drink	No	490	1.20	2.33
	Yes	256	1.44	2.53
Other fruit drink	No	487	2.31	2.87
	Yes	254	2.17	2.88

Mean frequency and standard deviation of weekly consumption of specified drinks at 15-months by any evidence of erosion at 61-months

Drinks at 15-m	**Any erosion**	**n**	**Mean**	**SD**
Cola	No	478	0.12	0.43
	Yes	247	0.20	0.58
Other carbonated drinks	No	478	0.21	0.78
	Yes	248	0.29	0.90
Apple juice	No	469	1.65	3.89
	Yes	248	1.64	4.05
Blackcurrant or rosehip drink	No	461	2.98	4.53
	Yes	243	3.18	5.18
Other fruit juice	No	461	3.13	4.34
	Yes	237	2.77	3.48
Other fruit drink	No	459	4.28	5.95
	Yes	244	5.76	6.63

Mean frequency and standard deviation of weekly consumption of specified drinks at 24-months by any evidence of erosion at 61-months

Drinks at 24-m	Any erosion	n	Mean	SD
Cola	No	475	0.72	1.69
	Yes	241	1.10	2.53
Other carbonated drinks	No	473	0.98	1.79
	Yes	236	1.63	3.57
Apple juice	No	470	1.71	4.14
	Yes	244	1.71	4.43
Blackcurrant or rosehip drink	No	474	3.22	5.82
	Yes	239	3.85	7.43
Other fruit juice	No	459	3.79	4.88
	Yes	232	3.82	5.43
Other fruit drink	No	474	7.53	8.82
	Yes	233	8.70	8.95
ALL carbonated drinks	No	467	1.73	2.85
	Yes	233	2.70	4.77
ALL non-carbonated drinks	No	443	20.0	13.64
	Yes	215	22.4	15.60
ALL drinks	No	432	21.73	14.10
	Yes	208	24.59	16.61

Mean frequency and standard deviation of weekly consumption of specified drinks at 6-months by palatal incisor erosion at 61-months

Drinks at 6-m	Palatal incisor erosion	n	Mean	SD
Cola	No	547	0.003	0.060
	Yes	258	0.008	0.088
Other carbonated drinks	No	548	0.003	0.060
	Yes	258	0.008	0.088
Apple juice	No	537	0.60	1.62
	Yes	255	0.80	2.06
Blackcurrant or rosehip drink	No	533	1.17	2.31
	Yes	250	1.46	2.55
Other fruit drink	No	531	2.31	2.87
	Yes	249	2.12	2.85

Mean frequency and standard deviation of weekly consumption of specified drinks at 15-months by palatal incisor erosion at 61-months

Drinks at 15-m	Palatal incisor erosion	n	Mean	SD
Cola	No	521	0.14	0.52
	Yes	242	0.21	0.58
Other carbonated drinks	No	521	0.22	0.82
	Yes	243	0.27	0.88
Apple juice	No	509	1.59	3.77
	Yes	243	1.61	4.06
Blackcurrant or rosehip drink	No	503	2.96	4.55
	Yes	238	3.23	5.22
Other fruit juice	No	500	3.08	4.26
	Yes	232	2.78	3.51
Other fruit drink	No	502	4.34	5.97
	Yes	239	5.77	6.65

Mean frequency and standard deviation of weekly consumption of specified drinks at 24-months by palatal incisor erosion at 61-months

Drinks at 24-m	Palatal incisor erosion	n	Mean	SD
Cola	No	516	0.70	1.64
	Yes	235	1.12	2.55
Other carbonated drinks	No	515	1.10	2.22
	Yes	230	1.67	3.61
Apple juice	No	511	1.64	4.01
	Yes	238	1.73	4.49
Blackcurrant or rosehip drink	No	513	3.25	5.79
	Yes	233	3.92	7.50
Other fruit juice	No	498	3.84	4.95
	Yes	226	3.80	5.48
Other fruit drink	No	513	7.58	8.71
	Yes	228	8.76	9.00
ALL carbonated drinks	No	508	1.82	3.07
	Yes	227	2.76	4.81
ALL non-carbonated drinks	No	479	20.25	14.00
	Yes	210	22.53	15.76
ALL drinks	No	467	22.10	14.63
	Yes	203	24.75	16.76

Mean frequency and standard deviation of weekly consumption of specified drinks at 6-months by labial incisor erosion at 61-months

Drinks at 6-m	Labial incisor erosion	n	Mean	SD
Cola	No	767	0.004	0.06
	Yes	31	0.003	0.18
Other carbonated drinks	No	768	0.004	0.06
	Yes	31	0.003	0.18
Apple juice	No	755	0.68	1.80
	Yes	31	0.39	1.31
Blackcurrant or rosehip drink	No	746	1.24	2.37
	Yes	31	2.10	2.98
Other fruit drink	No	746	2.29	2.89
	Yes	30	1.87	2.61

Mean frequency and standard deviation of weekly consumption of specified drinks at 15-months by labial incisor erosion at 61-months

Drinks at 15-m	Labial incisor erosion	n	Mean	SD
Cola	No	728	0.16	0.55
	Yes	29	0.14	0.44
Other carbonated drinks	No	728	0.24	0.85
	Yes	29	0.17	0.60
Apple juice	No	718	1.66	3.98
	Yes	28	1.04	3.80
Blackcurrant or rosehip drink	No	709	2.98	4.72
	Yes	28	4.75	5.93
Other fruit juice	No	700	3.01	4.07
	Yes	29	2.34	2.57
Other fruit drink	No	705	4.72	6.18
	Yes	29	6.48	7.02

Mean frequency and standard deviation of weekly consumption of specified drinks at 24-months by labial incisor erosion at 61-months

Drinks at 24-m	Labial incisor erosion	n	Mean	SD
Cola	No	718	0.79	1.94
	Yes	28	1.57	2.54
Other carbonated drinks	No	712	1.17	2.40
	Yes	28	2.11	3.65
Apple juice	No	715	1.72	4.24
	Yes	29	0.86	2.67
Blackcurrant or rosehip drink	No	714	3.39	6.14
	Yes	28	6.04	10.87
Other fruit juice	No	694	3.82	5.10
	Yes	26	3.46	5.14
Other fruit drink	No	710	7.74	8.70
	Yes	27	11.74	10.50
ALL carbonated drinks	No	703	1.96	3.41
	Yes	27	3.81	5.48
ALL non-carbonated drinks	No	662	20.78	14.60
	Yes	23	22.83	14.12
ALL drinks	No	645	22.70	15.36
	Yes	21	24.19	12.75

Mean frequency and standard deviation of weekly consumption of specified drinks at 6-months by molar incisor erosion at 61-months

Drinks at 6-m	Molar incisor erosion	n	Mean	SD
Cola	No	737	0.005	0.07
	Yes	17	0.00	0.00
Other carbonated drinks	No	738	0.008	0.10
	Yes	17	0.00	0.00
Apple juice	No	728	0.69	1.80
	Yes	15	0.27	1.03
Blackcurrant or rosehip drink	No	721	1.30	2.41
	Yes	17	0.76	1.68
Other fruit drink	No	718	2.30	2.88
	Yes	15	3.27	3.22

Mean frequency and standard deviation of weekly consumption of specified drinks at 15-months by molar incisor erosion at 61-months

Drinks at 15-m	Molar incisor erosion	n	Mean	SD
Cola	No	698	0.15	0.48
	Yes	16	0.31	1.01
Other carbonated drinks	No	700	0.22	0.80
	Yes	16	0.63	1.36
Apple juice	No	691	1.70	4.10
	Yes	16	1.38	2.42
Blackcurrant or rosehip drink	No	680	2.93	4.61
	Yes	16	3.81	4.81
Other fruit juice	No	674	3.06	4.12
	Yes	16	2.44	2.37
Other fruit drink	No	677	4.75	6.14
	Yes	16	6.56	6.50

Mean frequency and standard deviation of weekly consumption of specified drinks at 24-months by molar incisor erosion at 61-months

Drinks at 24-m	Molar incisor erosion	n	Mean	SD
Cola	No	691	0.80	1.91
	Yes	17	2.12	4.15
Other carbonated drinks	No	685	1.18	2.50
	Yes	17	2.59	4.09
Apple juice	No	688	1.76	4.26
	Yes	17	2.35	6.78
Blackcurrant or rosehip drink	No	691	3.37	6.25
	Yes	16	2.38	4.50
Other fruit juice	No	668	3.71	4.90
	Yes	17	5.29	6.78
Other fruit drink	No	681	7.94	9.01
	Yes	16	11.06	9.71
ALL carbonated drinks	No	676	2.00	3.46
	Yes	17	4.71	7.86
ALL non-carbonated drinks	No	635	20.57	13.98
	Yes	15	27.40	24.99
ALL drinks	No	617	22.36	14.55
	Yes	15	32.67	26.85

Appendix 8.1

Combinations of anterior and posterior occlusions for each clinic

31-month clinic No anterior open bite (642 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	557
Yes	No	16
No	Yes	12
No	Not determined	3
Yes	Yes	2
Not determined	Not determined	52

31-month clinic Symmetrical anterior open bite (128 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	80
Yes	No	17
No	Yes	12
Yes	Yes	12
Not determined	Not determined	7

31-month clinic Right anterior open bite (29 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	12
Yes	No	6
No	Yes	8
Yes	Yes	2
Not determined	Yes	1

31-month clinic Left anterior open bite (18 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	10
Yes	No	3
No	Yes	5

31-month clinic Undetermined anterior open bite (50 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	7
Yes	No	1
Yes	Yes	1
Not determined	No	1
Not determined	Not determined	40

43-month clinic No anterior open bite (673 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	595
Yes	No	29
No	Yes	22
No	Not determined	7
Not determined	No	2
Yes	Yes	5
Not determined	Not determined	13

43-month clinic Symmetrical anterior open bite (141 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	106
Yes	No	16
No	Yes	11
Yes	Yes	3
No	Not determined	1
Yes	Not determined	1
Not determined	Not determined	3

43-month clinic Right anterior open bite (16 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	9
Yes	No	3
No	Yes	4

43-month clinic Left anterior open bite (7 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	3
Yes	No	1
Yes	Yes	1
Not determined	No	1
No	Yes	1

43-month clinic Undetermined anterior open bite (30 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	9
Yes	No	1
No	Yes	1
Not determined	Not determined	19

61-month clinic No anterior open bite (764 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	671
Yes	No	40
No	Yes	33
No	Not determined	3
Yes	Yes	5
Not determined	No	1
Not determined	Not determined	11

61-month clinic Symmetrical anterior open bite (87 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	62
Yes	No	11
No	Yes	11
Yes	Yes	1
Not determined	Not determined	2

61-month clinic Right anterior open bite (2 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	1
Yes	No	1

61-month clinic Left anterior open bite (3 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	2
No	Yes	1

61-month clinic Undetermined anterior open bite (11 cases)

Right posterior crossbite	Left posterior crossbite	Number of cases
No	No	4
Yes	No	1
Not determined	No	1
Not determined	Not determined	5

Appendix 8.2

Summary of the influence of digit habits on the occlusal features of the children at the 31-, 43- and 61-month clinics when p<0.05, using information from Tables 8.24 to 8.39

	digit at 15-months		digit at 24- months		digit at 36- months		persistent digit habit	
	p value if <0.05	larger proportion of suckers have:	p value if <0.05	larger proportion of suckers have:	p value if <0.05	larger proportion of suckers have:	p value if <0.05	larger proportion of suckers have:
U31			0.036	Spacing				
L31								
A31								
Xbite31								
U43	0.035	Spacing	0.002	Spacing	0.022	Spacing	0.001	Spacing
L43								
A43			0.002	Open Bite	<0.0001	Open Bite	0.029	Open Bite
Xbite43					0.029	Crossbite		
U61	0.017	Spacing	0.023	Spacing			0.013	Spacing
L61								
A61	<0.0001	Open Bite	<0.0001	Open Bite	<0.0001	Open Bite	<0.0001	Open Bite
Xbite61					0.003	Crossbite	0.044	Crossbite

Summary of the influence of dummy habits on the occlusal features of the children at the 31-, 43- and 61-month clinics when p<0.05, using information from Tables 8.40 to 8.55

	dummy at 15- months		dummy at 24- months		dummy at 36- months		persistent dummy habit	
	p value if <0.05	larger proportion of suckers have:	p value if <0.05	larger proportion of suckers have:	p value if <0.05	larger proportion of suckers have:	p value if <0.05	larger proportion of suckers have:
U31								
L31	<0.0001	Spacing	<0.0001	Spacing				
A31	<0.0001	Open Bite	<0.0001	Open Bite				
Xbite31	<0.0001	Crossbite	<0.0001	Crossbite				
U43			0.012	No Spacing			0.032	No Spacing
L43					0.001	Spacing		
A43	<0.0001	Open Bite	<0.0001	Open Bite	<0.0001	Open Bite	<0.0001	Open Bite
Xbite43	<0.0001	Crossbite	<0.0001	Crossbite	<0.0001	Crossbite	<0.0001	Crossbite
U61	<0.0001	No Spacing	<0.0001	No Spacing	<0.0001	No Spacing	<0.0001	No Spacing
L61								
A61	0.003	Open Bite	<0.0001	Open Bite	<0.0001	Open Bite	<0.0001	Open Bite
Xbite61	<0.0001	Crossbite	<0.0001	Crossbite	<0.0001	Crossbite	<0.0001	Crossbite